Evaluation of visual health communication materials: The role of format, numeracy and health motivation

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Contents

Tables

Figures

I
General introduction

Be careful about reading health books. You may die of a misprint. (Mark Twain)

Health and diseases have always accompanied humans. Although the diseases that people suffer from may have changed over time, being healthy remains a key goal for everyone. Health, therefore, is an important topic to speak, read and hear about for humans all over the world. However, health communication can only have an impact on one's health if the message is heard, read and understood.

This dissertation aims to evaluate health communication materials to investigate whether and how these materials are used and understood. This general introduction will give an overview of the rather large field of health communication and explain which areas of health communication were studied. This part of the dissertation is structured as follows: first, the general relevance of the field of health communication will be described and the theoretical framework used for this evaluation will be presented. Second, the reasons why the areas studied in this dissertation were chosen will be explained. Finally, the relevant literature will be summarized and the research questions examined in the studies presented in this dissertation will be described.

1.1 Why study health communication?

To explain why health communication should be studied at all, it is important to first take a look at the way that many modern societies define health and treat diseases. In the preamble to its constitution, the World Health Organisation (1948) defines health as ‘a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity’. Corresponding to this definition, modern approaches in medicine and health psychology are based on a bio-psycho-social model of health and disease (e.g., Gutzwiller & Jeanneret, 1999; Schwarzer, 2004). These models assume that, in addition to biomedical factors, an individual’s health or illness is also influenced by factors such as personality, stress, health behaviour and many more (Schwarzer, 2004). Thus, diseases are not only treated after they appear, but can also be prevented before they appear at all. As a consequence, there are more and more efforts to promote a healthy lifestyle to prevent illnesses from developing and to detect illnesses and/or unhealthy situations as early as possible in order to minimize the effects of the illness (Gutzwiller & Jeanneret, 1999; Gutzwiller, Jeanneret, Abelin, Ackermann-Liebrich, Paccaud & Rougemont, 1999).

The most important aspect of disease prevention and health promotion is probably people’s health behaviours, for the following reasons: first, it influences a myriad of health outcomes. For example, eating habits, levels of exercise and smoking can influence a person’s risk for cancer, coronary heart disease or obesity (Schwarzer, 2004). Second, health behaviour is accessible to health promotion and disease prevention efforts, because some parts of health behaviour can be controlled more or less consciously by every individual. There are many health psychological models that explain why an individual engages in certain health behaviours or not (see Schwarzer, 2004 for an overview). Although these models differ in the factors they take into account, several of them contain health communication as a factor that influences people’s health behaviour in some way. For example, the health belief model includes mass media campaigns as one of several possible cues to action that influence the perceived threat of a certain disease, which then influences the probability of an individual’s acting to prevent this disease (Janz & Becker, 1984). Similarly, protection motivation theory includes environmental information sources that, amongst others, cause the individual to judge whether a threat is severe enough and whether the action against the disease is acceptable enough to engage in a certain health behaviour (Maddux & Rogers, 1983; Rippetoe & Rogers, 1987). In addition to this theoretical significance that is given to health communication, its practical importance has also been recognised. The World Health Organisation (2005) mentions in the Bangkok Charter of Health Promotion in a Globalized World that better communication technology is one of the advantages of globalization that has the potential to improve health promotion internationally. In sum, health communication is an important tool for health promotion and disease prevention because it provides the opportunity to reach crucial audiences and to convey the messages necessary to influence intentions and behaviours.

The more often health information is addressed to and used by the public, the more important it is that the messages provided by health communicators are understood correctly. However, not every health communication message is automatically understood - a fact that can have a large effect on people's health behaviour and, as a consequence, on people's health. As an example of the impact that ineffective health communications can have, Berry (2004) describes the pill scare in which the risk for thrombosis as a side-effect of third generation oral contraceptives was described as being almost double that of second generation oral contraceptives and resulted in the decreased use of the pill (see also Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz & Woloshin, 2007). In truth, the absolute risk of the described side-effect was rather small for both of these medication generations (15 vs. 25 cases per year per 100'000 users; Berry [2004], p. 38). Nevertheless, the message regarding the relative risk increase which was conveyed in the media, mostly without reference to the small change in absolute risk, led to more pregnancies and pregnancy terminations (Berry, 2004). This shows that the way that medical information is communicated can have a major impact on an individual's intentions, behaviours and health. As a consequence, health communication materials should be carefully designed and evaluated. The general aim of this dissertation is to contribute to the evaluation of health communication materials. The next section describes the theoretical framework used for this dissertation.

1.2 Evaluation of health communication

Thomas (2006) distinguishes between formative and summative evaluations of health communication. Whereas summative evaluations give information regarding the outcome of a communication campaign (i.e. whether the communication campaign showed the expected consequences), formative evaluations give information regarding how well the process of communication worked (Thomas, 2006). This dissertation is focused on the second type of evaluation and examines the processing of visual health communication materials. The framework by Grunert and Wills (2007) was used as a theoretical framework for this evaluation (see Figure 1.1).

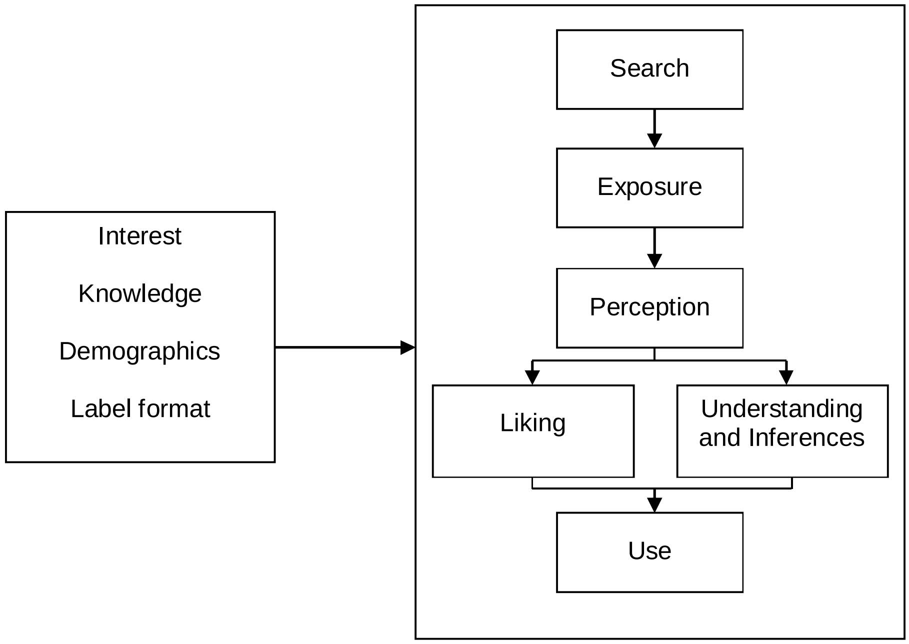

Figure 1.1 Slightly modified theoretical framework used by Grunert & Wills (2007)

This framework was originally designed to explain the process needed before people will begin to use information on food labels. However, it can easily be applied to different health communication materials as it explains the process of health communication rather generically. It is based on the assumption that health information does not automatically translate into healthier behaviour, but that several steps are necessary before this can happen. For example, the health communication message must be seen or heard by someone, processed and understood, before it can have the intended impact. Furthermore, several factors, such as interest and knowledge, influence this entire process (for a more detailed description of the model see Grunert & Wills, 2007). Based on these assumptions, this dissertation contains several studies concerning whether the format chosen for communication draws any attention (search/perception; see Chapter 3.2), how different formats are processed (perception/influencing factors; see Chapters 2.1 and 3.3), how interpersonal differences and aims influence the use and processing of health communication formats (influencing factors; see Chapters 2.1, 2.2, 3.1, 3.2) and how different formats of health communication materials influence the understanding of health information materials (understanding and inferences, see Chapters 2.2 and 3.3). Therefore, the focus of this dissertation is the diverse attention processes of health communication materials as well as their determinants.

The following methods were used in this dissertation to examine the health communication materials: first, self-report measures were used to study people's use and perception of health communication materials. A survey study was conducted. This instrument offers the advantage, that one can quickly and rather inexpensively reach a large sample and pose a large number of questions (Manstead & Semin, 2002). Therefore, the interplay of a large number of determinants of the self-reported use of health communication materials was measured with this instrument. In order to generate ideas about the perception process, half-standardized interviews were conducted to explore how people process graphical formats of health communication. Such self-report measures, however, have the disadvantages that they are reactive, that they are influenced by social desirability and that humans have difficulties in assessing their own skills, behaviours and characteristics (Dunning, Heath & Suls, 2004; Manstead & Semin, 2002). Therefore, other methods were used to compensate for these potential weaknesses and strengthen the validity of the results (Manstead & Semin, 2002). Where existing results allowed hypotheses about the roles of certain influencing factors in the processing and understanding of health communication materials, experimental designs were used to systematically examine causal relationships between these variables (Manstead & Semin, 2002). Finally, a video-based combined pupil/corneal reflection eye tracker was used for several studies exploring the visual processing of health communication materials. This instrument calculates the direction and duration of participants' gazes on visual stimuli by measuring corneal reflections relative to the centre of the pupil (see Duchowsky, 2007 for a more detailed description of this instrument). Studies using this instrument have shown that people use more and longer gazes when looking at complex graphs, because they require more cognitive processing to perceive them (Carpenter & Shah, 1998; Ratwani, Trafton & Boehm-Davis, 2008; Renshaw, Finlay, Tyfa & Ward, 2004). Therefore, in this dissertation, the eye tracker was used to evaluate the efficiency and complexity of visual health communication materials. In sum, all these methods resulted in several studies that are presented in Chapters 2.1 to 3.3. As the field of health communication is a broad one, the choice of areas to study was not obvious. The next section explains which areas of health communication were examined and on which criteria this choice was based.

1.3 Which areas of health communication were studied?

According to Thomas (2006), effective health communication a) improves people's health status when they are affected by a certain acute or chronic disease, b) reduces differences in health care due to situational factors, such as sociodemographic status and c) enhances disease prevention and health promotion. Similarly, modern public health approaches differentiate between primary prevention (avoiding the appearance of diseases), secondary prevention (early detection of diseases or risk factors) and tertiary prevention (prevention of secondary diseases or relapses; Gutzwiller & Jeanneret, 1999). Corresponding to these definitions, health communication materials must be adapted for situations in which diseases are or might be present as well as for situations in which there is no illness, but in which a healthy lifestyle should be promoted. Therefore, in this dissertation, typical health communication materials from both of these contexts are examined.

First, when disease is present or might be present, one important aspect of doctor-patient communication is counselling patients with regard to treatment decisions (Ong, De Haes, Hoos & Lammes, 1995). One very important communicative task for doctors in this situation is to provide patients with adequate information regarding medical tests and treatments as well as about the associated risks (Thomson, Edwards & Grey, 2005; van den Borne, 1998). There are many formats for visual health communication materials that are recommended to support doctors with this difficult task (see Section 1.4.2). Therefore, the evaluation of such materials in the context of medical test results and treatments is the focus of Part II of this dissertation.

Second, regarding the choice of an area in the field of disease prevention/health promotion, it was important to take into account that there has been a shift in the mortality and morbidity structure of Western societies the during the last century (Botschaft zum Bundesgesetz über Prävention und Gesundheitsförderung [Präventionsgesetz PrävG]), 2009; Thomas, 2006). Currently, chronic diseases and/or illnesses caused by lifestyle play a much larger role than contagious diseases that were more important at the beginning of the 20th century (Botschaft zum Bundesgesetz über Prävention und Gesundheitsförderung [Präventionsgesetz PrävG]), 2009; Thomas, 2006). In Switzerland, cancer and cardiovascular diseases are the two leading causes of lost live years (Botschaft zum Bundesgesetz über Prävention und Gesundheitsförderung [Präventionsgesetz PrävG]), 2009). A mutual risk factor for both of these conditions consists of eating an unhealthy diet and obesity (Petermann & Pudel, 2003; Schwarzer, 2004). Thus, nutrition communication is a very important area of health communication. This is especially true because the prevalence of obesity has been increasing in Switzerland over the last two decades (Schneider, Venetz & Gallani Berardo, 2009). Therefore, nutrition communication is studied in Part III of this dissertation.

As doctor-patient communication and nutrition communication differ largely with regard to the context and formats in which they are used, the relevant literature for both of these topics is reviewed separately in the next sections. First, the special characteristics of the communication situation between doctors and patients and the visual formats recommended for doctor-patient communication are described (see Section 1.4). Subsequently, the same structure is used for the nutrition communication materials examined in this dissertation (see Section 1.5).

1.4 When disease might be present - doctor-patient-communication

1.4.1 Characteristics of health communication between doctors and patients

Although mass media and the Internet have become important sources of health information, physicians have remained an important and trusted information provider for many patients (Fox & Rainie, 2000; Hesse, Nelson, Kreps, Croyle, Arora, Rimer & Viswanath, 2005; Johnson Avery, 2010; McMullan, 2006; Metsch, McCoy, McCoy, Pereyra, Trapido & Miles, 1998). However, the roles of doctors and patients in the doctor-patient interaction process have changed during the last century from a rather paternalistic role of the physician, who told the patient what to do, towards a more patient-centred and consumer-oriented relationship (Berry, 2004; Charles, Gafni & Whelan, 1999; Thomas, 2006; Thomson et al., 2005).

According to such modern patient-centred approaches, patients are expected to actively participate in the decisions concerning their health and/or illnesses (van den Borne, 1998). Under the more extreme versions of these approaches, called *informed* decision making, patients should be enabled to make decisions ‘where a reasoned choice is made by a reasonable individual using relevant information about the advantages and disadvantages of all the possible courses of action, in accord with the individual’s beliefs’ (Bekker, Lilleyman, Thornton, MacIntosh, Airey, Maule, Connelly, Michie, Hewison, Pearman & Robinson, 1999, p. iii). The role of the doctor is thereby reduced to that of a mere informant who provides patients with the necessary informational basis for his/her decision (Charles et al., 1999). However, there are also less strict approaches, such as the approach of *shared* decision making, which defines medical decision making as a process by which doctors and patients reach decisions together (Charles et al., 1999).

Both the approach of informed decision making as well as the approach of shared decision making show that the role of the doctor as a communicator is a crucial one because he/she is expected to provide the patients with all the information necessary to reach this decision (Charles et al., 1999). This shows that, compared to times when the paternalistic model was more common than patient-centred ones, doctors are now faced with new demands because they are increasingly confronted with the task of explaining the risks of treatments and other medical information to patients (Thomson et al., 2005; van den Borne, 1998). This is not an easy task. Medical information communication in the context of test results and the risks of treatments, henceforth synonymously called risk communication, often consists of numerical probability information. A large body of literature shows that many people, including medical doctors, have difficulties in understanding this type of information (see Gigerenzer et al., 2007; Hoffrage, Lindsey, Hertwig & Gigerenzer, 2000; Lipkus, 2007; Visschers, Meertens, Passchier & de Vries, 2009 for reviews of this literature). A group that is especially challenged by risk information consists of people with low numeracy, the lowered ability to understand and use numbers (see Lipkus & Peters, 2009; Peters, 2008 for reviews of this literature). Therefore, the next section gives an overview of this important concept in the context of medical risk communication.

1.4.2 Numeracy in the context of medical risk communication

There is a growing body of research that shows that numeracy is of utmost importance for doctor-patient communication. For example, low numeracy has been found to be associated with lowered comprehension of risk information about cancer (Davids, Schapira, McAuliffe & Nattinger, 2004; Donelle, Hoffman-Goetz & Arocha, 2007; Schwartz, Woloshin, Black & Welch, 1997) or medication side-effects (Gardner, McMillan, Raynor, Woolf & Knapp, 2011; Zikmund-Fisher, Ubel, Smith, Derry, McClure, Stark, Pitsch & Fagerlin, 2008b) as well as with unfavourable decisions regarding drug prescriptions plans (Tanius, Wood, Hanoch & Rice, 2009). Furthermore, there are some results indicating that disease-specific numeracy skills may also be associated with negative health outcomes. For example, low numeracy has been shown to be associated with worsened anticoagulation control (Estrada, Martin-Hryniewicz, Peek, Collins & Byrd, 2004) and with the unfavourable management of chronic diseases, such as asthma and diabetes (Apter, Cheng, Small, Bennett, Albert, Fein, George & Van Horne, 2006; Cavanaugh, Huizinga, Wallston, Gebretsadik, Shintani, Davis, Gregory, Fuchs, Malone, Cherrington, Pignone, DeWalt, Elasy & Rothman, 2008; Krishnavathana & Heptulla, 2010). Finally, it is possible that self-assessed numeracy also influences doctor-patient communication itself. In a study by Ciampa, Osborn, Peterson and Rothman (2010), participants with low self-reported numeracy perceived the communication with their doctors as less satisfying than persons with high self-reported numeracy. All these results suggest that health communication materials should be evaluated with a special focus on patients with low numeracy.

Therefore, the studies presented in Part II of this dissertation (Chapter 2.1 and 2.2) focus on numeracy as an important variable in the context of doctor-patient communication. To examine this aspect in more detail, a second theoretical framework was used for Part II in addition to the general framework by Grunert and Wills (2007) described in Section 1.2. This framework, the model of numeracy and the comprehension and use of numeric risk information by Peters (2008), provides an explanation of why persons with high and low numeracy may react differently to medical information (see Figure 1.2). In this model, Peters (2008) explains the difference in decision making based on numbers between persons with high and low numeracy as manifestations of different attention processes. The model postulates that persons with high numeracy pay more attention to the numbers in risk information, which then leads them to a better understanding of the numbers and also of the meaning behind these numbers (Peters, 2008). Persons with low numeracy, on the other hand, pay more attention to other information and are therefore more prone to biases (Peters, 2008).

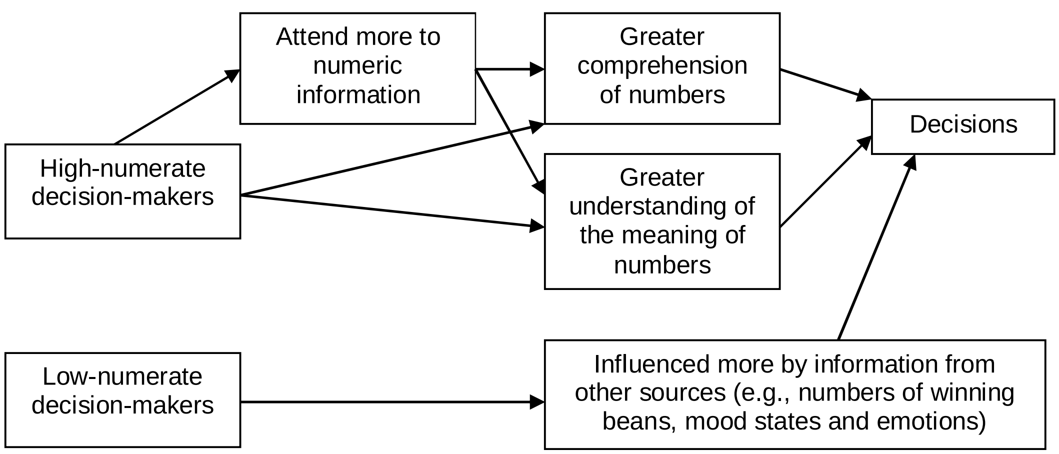

Figure 1.2. Theoretical framework of numeracy and comprehension and use of numeric risk information used by Peters (2008; p. 6)

In sum, medical doctors are often confronted with a difficult situation. They must explain information regarding risks and test results that are poorly understood by patients and that even they themselves have difficulty understanding. Nevertheless, it is expected of doctors, under the modern approaches of informed and shared decision making, that they fully inform their patients, despite any potential difficulties caused, for example, by a patient's low numeracy. To improve this situation and help doctors with this difficult task, there are recommendations regarding which formats and materials to choose for improving health communication generally and/or specifically for communication with persons with low numeracy. These formats are described in the next section.

1.4.3 Formats of doctor-patient communication

There are many different formats used for the communication of medical information or risks in general, and all of them have special characteristics and evoke different reactions and perceptions (see Berry, 2004; Gigerenzer et al., 2007; Lipkus, 2007; Visschers et al., 2009 for reviews of this literature). Graphical formats are widely seen as useful in improving risk communication (Lipkus, 2007; Paling, 2003; Visschers et al., 2009), especially for communications with persons with low numeracy (Apter, Paasche-Orlow, Remillard, Bennett, Ben-Joseph, Batista, Hyde & Rudd, 2008; Nelson, Reyna, Fagerlin, Lipkus & Peters, 2008; Peters, 2008). As numeracy is an important aspect of the studies in Part II, this introduction focuses on this type of communication material, whereas verbal and numerical formats are beyond the scope of this dissertation. See the above mentioned reviews for more information about verbal and numerical formats.

Graphs are recommended because they offer the advantages that they ease the depiction of large amounts of data, that they provide additional information about the data (e.g., trends) that may be hidden when only presented as numbers, that they can trigger calculations, that they can catch people's attention and that they create a better atmosphere for discussion (Lipkus, 2007; Lipkus & Hollands, 1999; Nelson et al., 2008; Paling, 2003; Visschers et al., 2009). There is a multitude of graphs that can be used for risk communication and each type has special characteristics that influence the comprehension and interpretation of the depicted risks in many different ways (see Ancker, Senathirajah, Kukafka & Starren, 2006; Berry, 2004; Lipkus & Hollands, 1999; Visschers et al., 2009 for reviews of this literature). As a result, many of these graphs are recommended for the communication of one special type of information. For example, line graphs are best for conveying trends over time, such as survival rates, and bar charts are suitable for the depiction of risk comparisons between subgroups or medications (Apter et al., 2008; Berry, 2004; Lipkus, 2007; Lipkus & Hollands, 1999; Nelson et al., 2008; Visschers et al., 2009). However, an ideal graph for doctor-patient communication should be applicable to a broader set of communication contents. Two such general and more flexible graphs are consistently recommended by several authors for doctor-patient communication, namely the Paling perspective scale (Ancker et al., 2006; Paling, 2003; Stallings & Paling, 2001) and pictographs (Apter et al., 2008; Lipkus, 2007; Nelson et al., 2008). Therefore, these two graphs were chosen for the two studies presented in Part II of this dissertation. The Paling perspective scale and the pictographs are described in more detail in the next two sections.

Paling perspective scale

The Paling perspective scale is especially designed and recommended for medical risk communication with patients (Lee, Paling & Blajchman, 1998; Paling, 2003; Singh & Paling, 1997; Stallings & Paling, 2001). It belongs to a type of graph called risk ladders which convey several levels of one risk or several different risks in an ascending order to depict a complete risk range and, in this way, allow for the depiction of risk comparisons (Ancker et al., 2006; Berry, 2004; Lipkus & Hollands, 1999; Visschers et al., 2009). This type of design is considered useful in helping people integrate a certain risk into a broader context so that they can better grasp its meaning (e.g., Singh & Paling, 1997; Stallings & Paling, 2001).

The Paling perspective scale consists of a panel that is divided into several sub-sections defined by a logarithmic scale (see Fig. 2.1.1 for a modified version of this scale). Within this panel, the risks to be communicated to a patient and several comparison risks can then be depicted. In this way, one can compare a risk that has to be communicated to a patient with several totally different, but probably more common and ‘tangible’, risks (e.g., the risk of a mother dying in birth compared to several accident risks or the risk of being struck by lightning; Stallings & Paling, 2001). Alternatively, one can also depict a person’s individual risk for a certain medical condition together with a comparison group’s risk regarding the same condition (e.g., the risk of a pregnant woman’s baby having Down syndrome compared to the average risk of Down syndrome for the baby of a woman in the same age group; Keller & Siegrist, 2009). Therefore, the Paling perspective scale is a flexible visual aid that can be individually tailored to every single patient.

However, despite these theoretical advantages of this scale, studies examining whether it actually has the potential to improve doctor-patient-communication are sparse. In a study by Lee and Mehta (2003), using the Paling perspective scale for the communication of the different the risks of blood transfusion (e.g., risk of HIV infection, risk of hepatitis infection) resulted in better knowledge of these risks in a post-test. Furthermore, two other studies compared the Paling perspective scale to pictographs and numerical formats in the context of the risk of a pregnant woman's baby having Down syndrome as well as the risk for a woman having colon cancer (Keller & Siegrist, 2009; Siegrist, Orlow & Keller, 2008b). The results of these studies suggest that the Paling perspective scale seems to evoke higher risk perceptions than the other formats and that it is useful in helping people to differentiate between a high and a low risk (Keller & Siegrist, 2009; Siegrist et al., 2008b). However, the Paling perspective scale was not superior to numerical formats when those also showed comparison information (Lee & Mehta, 2003; Siegrist et al., 2008b). Additionally, the only study that took numeracy into account suggested that the Paling perspective scale may only be useful for persons with high numeracy, because it did not help persons with low numeracy to differentiate between a high and a low risk (Keller & Siegrist, 2009).

To further examine the utility of the Paling perspective scale for communication with patients with low numeracy, a study was conducted based on the results described in this section (Chapter 2.1). It explored whether there was a difference between persons with high and low numeracy with regard to the visual processing of the Paling perspective scale by applying an eye tracker.

Pictographs

Pictographs depict how many persons are affected by a medical condition (e.g., a disease, side-effects of a certain medical treatment) within a larger group of persons (see e.g., Figures 2.2.1 or 2.2.2). Typically, these graphs depict a denominator of 100 or 1000 persons (see Schapira, Nattinger & McAuliffe, 2006; Zikmund-Fisher, Fagerlin & Ubel, 2008a; Zikmund-Fisher et al., 2008b for other examples of this type of graph). Within these arrays, one can depict one or more variable numerator(s) to communicate a risk message to patients. Several studies have shown that pictographs may have the potential to improve doctor-patient communication. First, when depicted in simple pictographs, numerical medical information regarding the side-effects of medical treatment as well as about the risks and benefits of treatment options and screening seems to be better understood than when communicated only by numbers or by other graphs (Galesic, Garcia-Retamero & Gigerenzer, 2009; Garcia-Retamero & Galesic, 2009; Hawley, Zikmund-Fisher, Ubel, Jancovic, Lucas & Fagerlin, 2008; Zikmund-Fisher et al., 2008a; Zikmund-Fisher et al., 2008b). Moreover, some of these studies found pictographs to be especially helpful for persons with low numeracy (Galesic et al., 2009; Garcia-Retamero & Galesic, 2009; Hawley et al., 2008). Thus, this type of graph seems to be a useful tool for doctors in communicating medical risk information to persons with high and low numeracy.

However, understanding the numbers depicted in a graph may not be enough to ensure informed decision making. Peters (2008) points out that it is possible that the challenge of numerical risk information for persons with low numeracy consists not only of understanding numerical risk information per se, but also of understanding the meaning of this information and of integrating this meaning into the decision making process (see also Figure 1.2). In terms of doctors and patients, this means that even when patients with low numeracy do understand the numerical information a doctor has given them, for example with the help of a pictograph, there is still no guarantee that they will be able to actually use this information in the medical decisions that they must make. Therefore, it may be useful to also examine what risk perceptions are evoked when people are given medical information depicted in a pictograph.

Studies have shown that risks are perceived as lower and less severe when depicted in pictographs as compared to numerical formats or the Paling perspective scale (Galesic et al., 2009; Keller & Siegrist, 2009; Siegrist et al., 2008b). However, it is difficult to go beyond such results because risk perception is subjective by nature and cannot be judged as being clearly right or wrong. One attempt to find out whether and how persons grasp the meaning of a risk information message consists of an experimental approach (Keller & Siegrist, 2009; Siegrist et al., 2008b). In this approach, participants are shown either a high or a low risk and then asked to estimate the magnitude of this risk. Whether the participants who had seen a low risk perceive this risk as lower than participants who had seen a high risk is then analysed. If the estimates differentiate between the two risk levels, one can assume that the communication format was successful in conveying a difference in meaning. Two studies followed this approach in order to examine whether this was the case with pictographs (Keller & Siegrist, 2009; Siegrist et al., 2008b). However, in these studies, pictographs showing a low risk did not evoke a lower risk perception than pictographs showing a high risk (Keller & Siegrist, 2009; Siegrist et al., 2008b). Furthermore, the role that numeracy plays in this process is not yet clear.

Based on these results, an additional study was conducted to further explore the association between numeracy and the understanding and processing of pictographs (see Chapter 2.2). It aimed to discover whether and in what form pictographs have the potential to be a useful tool for doctor-patient communication with patients with low numeracy.

1.5 Promoting a healthy lifestyle - nutrition communication

1.5.1 Characteristics of nutrition communication

Part III focuses on nutrition communication as a means of general health promotion to examine a typical example of a situation in which disease is not yet present and the aim is to promote a healthy lifestyle. Promoting healthy eating is a very important public health issue because eating an unhealthy diet and obesity are risk factors for many chronic diseases (Petermann & Pudel, 2003; Schwarzer, 2004). For example, being overweight and/or eating large amounts of trans-fatty acids and saturated fatty acids as well as eating a very salty diet increases the risk for cardiovascular diseases, whereas eating linoleic acid, fish and fish oils, fruits and vegetables and diets rich in potassium as well as a low to moderate level of alcohol consumption decreases this risk (Reddy & Katan, 2004). Furthermore, being overweight and drinking alcohol as well as probably also eating red or preserved meat or only small amounts of fruits and vegetables increases the risk of different cancer types (Key, Schatzkin, Willett, Allen, Spencer & Travis, 2004). Finally, overweight persons have a higher risk for developing type two diabetes (Steyn, Mann, Bennett, Temple, Zimmet, Tuomilehto, Lindström & Louheranta, 2004). This shows that general nutrition communication that informs people of how to maintain a balanced diet, with regard to all of the aspects described above and how to avoid obesity has the potential to decrease the risk of many diseases simultaneously.

However, the situation of nutrition communication is a special one because staying healthy is not the only reason for eating or choosing food products. In fact, it actually seems to be a rather unimportant factor as compared to other aspects of daily life - hedonic factors, such as taste, or more situational factors, such as hunger or prices, may be more important in determining people’s eating behaviours and food choices (Glanz, Basil, Maibach, Goldberg & Snyder, 1998; Grunert, Wills & Fernandez-Celemin, 2010b; Neumark-Sztainer, Story, Perry & Casey, 1999). Thus, the task of reaching the public, despite all these competing motivations, is a rather difficult one. Nevertheless, the aim of effective nutrition communication is to give people the opportunity to eat healthfully, if they want to, by making it easier to decide what is healthy and what is not (World Health Organisation, 2003). The formats in which nutrition communication can be used to reach this aim are described in more detail in the next section.

1.5.2 Formats of nutrition communication

There are two basic formats for nutrition communication in the context of health promotion that are used in Switzerland. Therefore, the three studies presented in Part III of this dissertation focus on these two formats. One possibility is to inform the consumers in the store of the nutritional contents (e.g., fat quality, salt and sugar content etc.) of the food they are buying by presenting this detailed information directly on the package of the food product (Swinburn, Caterson, Seidell & James, 2004; World Health Organisation, 2003). However, this measure alone is probably rather useless when people lack more general knowledge of how a healthy diet should be composed. A study by Dickson-Spillmann and Siegrist (2011) showed that there are indeed misconceptions in the general population concerning what a healthy diet should look like. Therefore, general food guides are used as a second format, depicting general guidelines regarding how to eat healthfully that are derived from the different disease risks described above (e.g., the food pyramid of the Swiss society for nutrition; Walter, Infanger & Mühlemann, 2007). In the following sections, the information that appears on packaging as well as food guides are described in more detail.

Information on packaging

According to the European Heart Network (2007), information about nutritional contents on packaging has the following specific aims: First, it should provide consumers with information regarding the nutrients contained in a certain product. Second, it should show consumers information about the healthiness of the product with regard to their overall diet. Third, it should enable them to compare different products with regard to nutrients and with regard to the products' healthiness. To reach all these aims, nutrition labels on packages should include consistent information about the product's nutrient contents. This information can be displayed either on the front of the package and/or on the back of the package (European Heart Network, 2007). Often, more detailed information can be found on the back of the package (usually, there is more space there), whereas more simplified information is presented on the front of the package (European Heart Network, 2007).

Back-of-package labels typically consist of a table or a short text that presents the most important nutrients numerically per 100g and/or per serving. Either there is information about a product's energy value as well as how much protein, carbohydrates and fat it contains (the so-called Big 4) or the information is a bit more detailed and contains information regarding the Big 4 plus sugars, saturates, fibre and sodium (the so-called Big 8; Hurt, 2002). This format has been widely used in many countries for several years, for example in Switzerland, Canada, Australia, the United Kingdom and the United States (e.g., Campos, Doxey & Hammond, 2011; Coop, n.d.; Lewis Taylor & Wilkening, 2008; Schweizerische Gesellschaft für Ernährung, 2010).

Front-of-package labels are a younger format and are more diverse in nature. Generally, there are two types of labels in this group: detailed ones showing information regarding several key nutrients and general labels that show only one type of information (European Heart Network, 2007; Lobstein & Davies, 2008; Ni Mhurchu & Gorton, 2007). Two widely used detailed front-of-package formats consist of GDAs (Guideline Daily Amounts) and traffic light labels (Lobstein & Davies, 2008). GDAs show a serving's calorie content as well as how much sugar, fat and salt a product contains and shows this amount of nutrients in relation to the amount of these nutrients that is required by the average healthy adult per day (Confederation of the Food and Drink Industries of the EU, n.d.; Coop, n.d.). Traffic light labels, on the other hand, use the traffic light colours (red, amber, green) to highlight whether a product contains a low, medium or high amount of certain nutrients (Food Standards Agency, 2007). General front-of-package labels show only one logo or one single message about the product to show how healthy it is (European Heart Network, 2007; Lobstein & Davies, 2008). This type of format consists of healthy choice logos that indicate products that are healthier as compared to products of the same product class (with regard to certain nutrients) or health claims showing single nutrient statements concerning the healthiness of a product (e. g., low-fat; European Heart Network, 2007; Lobstein & Davies, 2008; Ni Mhurchu & Gorton, 2007).

In sum, there are many different types of nutrition communication labels on contemporary food packages. However, these labels can only have an impact on public health if they are actually used by the consumers that buy the foods. Corresponding to the multitude of labels, there is a large body of research examining whether these labels are indeed used by the public (see Campos et al., 2011; Cowburn & Stockley, 2005; Drichoutis, Lazaridis & Nayga, 2006; European Heart Network, 2003; Grunert & Wills, 2007; Ni Mhurchu & Gorton, 2007 for reviews of this literature). These reviews consistently suggest that nutrition labels seem to be used by many customers (ranging from 47% to 82%, Campos et al, 2011). However, as self-reported label use, which was measured by most of the studies presented in these reviews, may lead to an over-estimation of label use as compared to more direct measures, such as verbal protocol analysis or in-store observations, these numbers are probably too high (Cowburn & Stockley, 2005; European Heart Network, 2003; Grunert & Wills, 2007; Ni Mhurchu & Gorton, 2007). For example, Grunert and colleagues (2010b) combined in-store observations and interviews with a self-report measure of nutrition label use and found that the direct measures resulted in label use for 27% of participants, whereas 47% of the participants claimed to use labels in the self-report measure. In another observational study, the same group found that only 17% of their participants used nutrition labels (Grunert, Fernandez-Celemin, Wills, Sorcksdieck genannt Bonsmann & Nureeva, 2010a).

Self-reported label use seems to be influenced by or is at least correlated with many different factors. First, review studies suggest that label use is associated with sociodemographic and economic factors. Women tend to use labels more frequently than men, as do persons of higher levels of education and/or income (Campos et al., 2011; Cowburn & Stockley, 2005; European Heart Network, 2003; Grunert & Wills, 2007). However, in studies that take into account several sociodemographic and situational factors at once, the role of these sociodemographic factors is no longer clear because there are no consistent associations between these factors and the frequency of label use (Drichoutis, Lazaridis & Nayga, 2005; Drichoutis, Lazaridis, Nayga, Kapsokefalou & Chryssochoidis, 2008; Kim, Nayga & Capps, 2001; Nayga, 2000; Nayga, Lipinski & Savur, 1998). For example, the studies that found a gender effect did not include the importance of price, nutrition and taste (Drichoutis et al., 2008; Kim et al., 2001), whereas studies including these aspects did not find a gender effect (Drichoutis et al., 2006; Nayga, 2000; Nayga et al., 1998).

Second, attitudes toward health and healthy eating seem to be important to label use (Campos et al., 2011; Cowburn & Stockley, 2005). For example, persons who place importance on nutrition and on following dietary guidelines use labels more often (Nayga, 2000; Nayga et al., 1998). Less label use, on the other hand, has been seen in persons who place importance on price or taste (Drichoutis et al., 2005). Finally, there are also factors that may hinder people's use of labels. Therefore, the reasons why people do not use labels should be considered as well. People seem to not use labels for many different reasons: because they are not interested in healthy eating, because they do not need more information about food, because they do not understand labels and because they have priorities other than healthy eating (Gorton, Ni Mhurchu, Chen & Dixon, 2009). Thus, in addition to examining sociodemographic and health-related variables, studies concerned with the use of labels should also take factors into account that are associated with the understanding of labels and with other priorities concerning eating.

Furthermore, as described above, most of the studies described so far have used self-report measures to examine whether labels are used at all and how often they are used. In the last few years, however, there have been attempts to study label use more directly with in-store observations, interviews, verbal protocol analyses or eye tracking, in order to get a more realistic picture of when and how the labels are used. For example, studies that used in-store observations, in-store interviews and verbal protocol analyses showed that label use depends on the type of product that is bought and that fat, sugar and calories seem to be the information that is sought most often on a label (Grunert et al., 2010a; Grunert et al., 2010b; Higginson, Rayner, Draper & Kirk, 2002b). An eye tracking study confirmed the importance of these three nutrients (Jones & Richardson, 2007). In another study, shoppers were accompanied, observed and interviewed with regard to their use of front-of-package labels while buying food (Malam, Clegg, Kirwan, McGinigal, Raats, Barnett, Senior, Hidgkins & Dean, 2009). Furthermore, the shoppers were ‘thinking aloud’ while shopping. This study showed that label use was inhibited by other information presented on the package as well as by other factors. Similarly, an eye tracking study suggested that characteristics of the label on the package, such as the size of the label and its location on the package, may influence the attention paid by individuals to the label (Bialkova & Van Trijp, 2010). Taken together, the results from the studies using direct measures of label use show that the product itself and probably also the design of the product influences the use of nutrition labels.

In sum, label use may be influenced by a myriad of different factors. However, as described in the context of sociodemographics, these factors may be interrelated. Therefore, some of the above-mentioned results may actually be artefacts. In order to evaluate the outreach of nutrition labels, further studies are needed to understand in more detail which factors influence whether people use labels when buying food. Ideally, these studies should use direct as well as self-report measures. Based on this conclusion, Part III describes two studies that were conducted to further explore which factors influence label use. First, the study presented in Chapter 3.1 examined a comprehensive model, consisting of sociodemographic, health-related and motivating/inhibiting factors associated with the understanding of labels, with other priorities concerning eating and with behavioural barriers to self-reported label use. The aim of this study was to complement existing models and to determine which of the predictors remain important in a comprehensive model of label use. Second, the study described in Chapter 3.2 consisted of an eye tracking experiment to directly examine whether health motivation influences the amount of visual attention paid to nutrition information on real food packages.

Food guides

Food guides are used in many countries to educate people about healthy eating (e.g., in Australia, Canada, Great Britain, Germany, China, the Philippines etc.; Painter, Rah & Lee, 2002). Typically, these food guides consist of a graph showing the composition of a healthy diet as well as additional text materials, such as brochures, that explain the depicted information in more detail (e.g. the food guides of Switzerland, Canada and Germany; Health Canada, n.d.; Stehle, 2007; Walter et al., 2007). All of these food guides are based on the same principle: food products are grouped into several food groups (e.g., liquids, fruits and vegetables, fats and oils etc.) and recommendations are given regarding how much of each group should be eaten daily in order for one's diet to be healthy (Painter et al., 2002). Therefore, the food guides used all over the world are rather similar and differ only in the food groups, the quantitative recommendations given and the type of graph used (Painter et al., 2002).

As the main aim of this dissertation is the formative evaluation of visual health communication materials, this introduction focuses on the different graphs used for the food guides. The graphical elements used in food guides look rather different from country to country and range from depictions of plates to rainbows to pagodas (Painter et al., 2002). However, the graphs have more in common than it seems at first sight. First, the graphical principle behind the graphs is normally the same. Usually, the graph consists of several areas depicting the different food groups. The larger the area, the more of this group should be eaten in a healthy diet. Second, most of these formats can be classified as being either hierarchical or circular. In hierarchical formats, the food groups are arranged from bottom to top, whereas in circle formats, the food groups are arranged in a circle with different sized sectors. Whereas all circle formats look similar (e.g., the German nutrition circle; Stehle, 2007), there are essentially two possible hierarchical formats. Either the food group one should eat the most of is at the bottom and the food group one should eat the least of is at the top of the graph or vice versa. The resulting graph then either resembles a pyramid (e.g., the pyramid of the Swiss society of nutrition; Walter et al., 2007) or a rainbow (e.g., the rainbow used in Canada's food guide; Health Canada, n.d.).

In sum, there are differences between existing food guides. However, as Painter and colleagues (2002) conclude, despite these differences, most food guides convey very similar information. Namely, that a healthy diet should be composed of large amounts of grains, fruits and vegetables, whereas meat and dairy products should be consumed in smaller amounts (Painter et al., 2002). Therefore, one would expect that all of these food guides are equally suited for nutrition communication. Nevertheless, there is an on-going discussion in the literature regarding which graphical format is the best for depicting information about healthy eating. For example, the pyramid is criticized by some authors because it displays the 'best thing' at the bottom and the 'worst thing' on the top or because it evaluates food groups as either 'good' or 'bad' (Leitzmann, 2004; Nestle, 1998; Rodrigues, Franchini, Graca & De Almeida, 2006). The circle, on the other hand, is attributed with more advantages in that it resembles a plate and stresses the composition of a healthy diet, instead of ranking the food groups (Rodrigues et al., 2006). However, this discussion has been a rather theoretical one because of a lack of empirical data regarding which one of the formats is superior to the other. The few studies that have compared the effectiveness of circle and pyramid formats showed mixed results. Some authors found the circle to be slightly superior (Hunt, Gatenby & Rayner, 1995), whereas others measured the pyramid to be slightly superior (Eissing & Lach, 2003). However, the graphs in the second study also differed in other features (e.g., type of pictures). Therefore, it is difficult to say whether these small differences were due to the different formats, or whether they appeared due to other characteristics of the graph.

All in all, food guide graphs have not been thoroughly evaluated to date. Therefore, further studies are needed to systematically compare the food guides with regard to the characteristics in which they differ, such as food groups, recommendations, graphical formats used, in order to help public health communicators pick the materials that are best suited for this aspect of nutrition communication. Graphical formats were examined in Chapter 3.3, in which a pyramid, a circle and a rainbow format were compared with regard to their effectiveness and efficiency in conveying information about a healthy diet. This and all other studies conducted during this dissertation project are briefly described in the next section in order to give a comprehensive overview over this dissertation.

1.6 Overview of this dissertation

This dissertation consists of four main parts. First, this general introduction gives an overview about the areas studied as well as about the most important results in these areas (Part I). The following two chapters describe studies evaluating visual health communication materials for doctor-patient communication (Part II) and for nutrition communication (Part III) that were conducted during this dissertation project. These two parts are described in more detail below. Finally, the results of these studies are then discussed comprehensively in the general discussion (Part IV). In addition, the implications for health communication as well as for further research are given in Part IV based on the results of Parts II and III.

Overview of Parts II and III

As described above (see Section 1.2), the theoretical framework by Grunert and Wills (2007) was used for both Part II and Part III because it explains the entire process of communication, from paying attention to the message to its use in one's actual behaviour and includes potential influencing factors on this process. This overview first describes which aspects of the Grunert and Wills (2007) framework were examined in Parts II and III. Subsequently, an overview of the five studies presented in Parts II and III is given.

Doctor-patient communication often concerns decisions that can have serious consequences for the patient. Thus, it was assumed that patients are generally motivated to listen to their doctor and to pay attention to the information he/she provides. Therefore, the studies in Part II focus more on the processing and understanding of the materials and less on whether patients actually pay attention to the message or not. As described above (see Section 1.4.2), graphs, especially the Paling perspective scale and pictographs, are seen as promising tools for the communication of medical risks to persons with low numeracy. However, empirical results showing that these graphs actually do help this group of individuals and in what way they do so are sparse. Therefore, the main aim of Part II is to examine the association between numeracy and medical risk communication with the Paling perspective scale (Chapter 2.1) and pictographs (Chapter 2.2).

The situation regarding nutrition communication is a very different one. Unlike doctor-patient-communication, in which most people are motivated to at least try to understand what the doctor is saying, because their health or even their life may be at stake, not all persons are interested in healthy nutrition, because there are many more reasons to eat than simply remaining healthy. First, it is not entirely clear whether nutrition labels, although broadly applied in many countries, are really used by the public. Therefore, the first aim of Part III is to examine whether people use this communication format at all and, if they do, to find out who does so and why they do it (Chapters 3.1 and 3.2). Second, only a few have studies evaluated food guide formats, although there is a theoretical discussion taking place regarding which format is the best one. Thus, the second aim of Part III is to examine the influence of a food guide's graphical format on its effectiveness and efficiency in conveying information about healthy eating (Chapter 3.3).

Table 1.1. Overview of the research questions examined and the methods used in this dissertation

Part II - When disease might be present - doctor-patient communication

Chapter contents and research questions	Investigated constructs	Methods
2.1 Visual attention to the Paling perspective scale (PPS) related to numeracy		
- Do people pay attention to the special characteristics of the PPS (risk comparisons, the logarithmic scale)? - Do persons with low numeracy have more difficulty processing the PPS than persons with high numeracy? - Do persons with low numeracy process the PPS less efficiently than persons with high numeracy?	Perception[1] Influencing factors[1]	Eye tracking
2.2 Processing the meaning of information depicted in pictographs related to numeracy		
- Do pictographs with/without reference information help participants to differentiate between a high and a low risk? - Do participants pay attention to the numbers depicted in pictographs and is there an association between attention paid to numbers and numeracy? - Does drawing low numerates' attention to the numbers in the pictograph help them differentiate between a high and a low risk?	Understanding and inferences[1] Influencing factors[1] Attention to numbers[2]	Experiment Interview

Part III - Promoting a healthy lifestyle - nutrition communication

Chapter contents and research questions	Investigated constructs	Methods
3.1 Testing a comprehensive model of nutrition label use - the role of sociodemographic, health-related and motivational aspects		
- What factors predict frequent nutrition label use? - What is the relative importance of the three predictor groups? - Are sociodemographic and economic variables mere proxies for underlying health-related motivators and inhibitors of label use?	Influencing factors[1]	Survey
3.2 Visual attention to nutrition information on food packages		
- How much attention do consumers pay to nutrition information on food products? - Does health motivation lead to paying increased attention to nutrition information on food products?	Influencing factors[1] Search/ Perception[1]	Eye tracking Experiment
3.3 Effectiveness and efficiency of three food guide formats (pyramid, rainbow, circle)		
- Are the three formats equally effective in conveying information about healthy eating? - Do the three formats differ with regard to the complexity or efficiency of processing, based on eye movement data?	Understanding and inferences[1] Perception[1] Influencing factors[1]	Eye tracking Experiment

[1]From the framework by Grunert and Wills (2007)
[2]From the framework by Peters (2008)

Chapter 2.1 - How do people perceive graphical risk communication? The role of subjective numeracy

As there are only few studies evaluating the Paling perspective scale (see Section 1.4.2), the processing of this scale was evaluated on an explorative and descriptive level in order to generate ideas about why this graph might or might not be helpful for persons with low numeracy. To measure the processing of the graph as directly as possible, an eye tracker was used for this study. This instrument measured the participants' gaze directions and gaze durations while they were reading a hypothetical scenario about a pregnant woman's risk of carrying a baby with Down syndrome. From these data, inferences about processing complexity and about which areas of the stimulus were paid more attention to than others could be made. The results suggest that patients may not use all the advantages of this scale, irrespective of whether they are high or low in numeracy. Furthermore, the gaze data suggest that the Paling perspective scale is difficult to process for persons with lower numeracy and that this group process the graph less efficiently. Therefore, the Paling perspective scale, though recommended for doctor-patient communication, should be used with care for risk communication with persons with low numeracy.

Chapter 2.2 - Risk communication with pictographs: the role of numeracy and graph processing

Pictographs seem to help persons with low numeracy to understand the numbers depicted in the graph, but they seem to be less helpful in conveying the meaning of this numerical risk information to persons with high or low numeracy (see Section 1.4.2). Therefore, three studies are described in this chapter to examine in more depth why this could be the case and what role numeracy may play in this process. The experimental approach of Siegrist and colleagues (2009; 2008b) described above was used to examine whether participants could draw meaning from the graph (see Section 1.4.2). Furthermore, the crucial assumption of Peters' (2008) model, that persons with high numeracy pay more attention to numerical information and understand its meaning better, was used to explore and explain the differences between persons with high and low numeracy with regard to extracting meaning from a pictograph. The results of the first study in this chapter suggest that, for persons with high numeracy, pictographs were helpful, whereas the graph was less helpful for persons with low numeracy, especially when it depicted a risk comparison. The second study in this chapter aimed to find an explanation for this rather surprising result. Therefore, the participants were interviewed about their processing of the pictographs. The results of this study suggested that persons with high numeracy tend to focus more on the numbers ‘hidden in the graph’ than persons with low numeracy. The third study in this chapter examined whether drawing participants’ attention to the numbers depicted in the graph would help them to better understand the meaning of the depicted risk. Again, the experimental approach of Siegrist and colleagues (2009; 2008b) was used (see Section 1.4.2). However, drawing participants’ attention to the numbers depicted in the graph did not help. On the contrary, drawing low numerates’ attention to the numbers decreased the utility of the pictographs for this group. All in all, the results of these studies suggest that persons with high numeracy rely more on the numbers depicted in this type of graph than persons with low numeracy and that pictographs should be as simple as possible for risk communication with persons with low numeracy.

Chapter 3.1 - The role of health-related, motivational and sociodemographic aspects in predicting food label use: a comprehensive study

To have an impact on public health, nutrition labels must be used by the public. However, it is not yet clear what influencing factors predict the frequency of label use. Previous studies have shown that sociodemographic variables and health-related factors are associated with nutrition label use (see Section 1.5.2). Additional factors that may hinder people’s use of labels have not been systematically included in these studies. Therefore, this chapter describes a survey study using a representative sample of the Swiss population to test a comprehensive model of the frequency of label use consisting of three predictor groups: sociodemographic variables, health-related aspects and inhibiting/motivational factors. The results suggest that health-related variables are the most important predictor group, followed by motivating factors, such as shopping habits and viewing eating as something positive, and sociodemographic variables. This means that to increase food label use, peoples’ interest in healthy eating should be increased. It should also be stressed that maintaining a healthy diet does not automatically mean abstaining from tasty food.

Chapter 3.2 - Health motivation and product design determine consumers’ visual attention to nutrition information on food products

Food label use may be over-estimated when only self-report measures are used (see Section 1.5.2). Therefore, an eye tracking study was conducted to examine in more detail how much attention people pay to nutrition information when they are looking at five different cereal packages that display not only food labels, but also other information, such as the product’s name. Furthermore, an experimental approach was used to test whether being motivated to choose healthy food products leads to increased attention being paid to information regarding the nutritional content of the product as compared to being motivated to choose tasty food. The results suggest that health motivation leads to more attention being paid to and a deeper processing of nutritional information on the package, whereas taste motivation may be associated with attention being paid to the package design and advertisements. Furthermore, the presence of other information on the package, such as advertisements, seems to distract people’s attention from nutrition information. Therefore, this study suggests that attention to nutritional information on the package can be increased by raising people’s health motivation and possibly also by using simple package designs that do not display much other information.

Chapter 3.3 - Effectiveness and efficiency of different shapes of food guides

There have been only few prior attempts to compare different food guide formats with regard to their relative effectiveness, and these comparisons were mostly unsystematic (see Section 1.5.2). Thus, it is not yet known which food guide format should be preferred for nutrition education. Therefore, three typical food guide shapes were evaluated with regard to their relative effectiveness and efficiency. For this, multiple methods were used to evaluate the formats on several dimensions. First, to measure effectiveness, an experiment was conducted to examine whether seeing a pyramid, a circle or a rainbow resulted in more correctly solved nutrition tasks. Second, to measure the three shapes’ efficiency, an eye tracker was used to examine whether one of the graphs was easier to process than the others or could be processed more quickly. The results suggest that the three graph formats do not differ with regard to effectiveness and efficiency overall, but the viewers’ attention was drawn to different parts of the graphs. In sum, it does not matter do a great degree which food guide is used in nutrition education, but communicators should be aware that some food groups may be more salient than others, depending on the type of graph that is used.

II
When disease might be present - doctor-patient communication

Chapter 2.1
How do people perceive graphical risk communication? The role of subjective numeracy

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Abstract

This study aims to evaluate directly how a graphical risk ladder is perceived and how this perception is related to people's subjective numeracy. Gaze durations and frequencies were used to examine visual attention. Participants (N = 47) appeared to focus on the target risk information, whereas referential information was less attended. Subjective numeracy was negatively correlated with total watching time and the absolute number of gaze events. Results suggest that participants with low subjective numeracy have more difficulty in comprehending the graph, and that they process the graphical information less efficiently than the participants with high subjective numeracy. In addition, the position of referential risks on risk ladders could influence people's risk perception. Based on these findings, we provide some implications for the design of risk communication graphs and for the use of graphs in informing persons with low subjective numeracy about risks.

Introduction

In today's Western society, people are confronted with many different everyday risks. These can range from potentially dangerous substances in the household to medical risks. In the medical domain, people have to decide whether to undergo a screening test for a certain disease or which medical treatment they should choose. Enabling patients to make informed decisions involves making such decisions based on well-understood information and corresponding to their own values (Marteau, Dormandy & Michie, 2001). This implies that doctors and/or medical counsellors have to fully inform patients about the risks of procedures and the meanings of test results. How risks can be successfully communicated is still an open question, however (Siegrist, Cousin & Keller, 2008a). In this paper, therefore, we examine people's visual attention to a risk communication graph that can be applied in medical decision making.

Graphical risk communication formats

Previous research has shown that people have substantial difficulties in understanding probability information (see Gigerenzer & Edwards, 2003; Lipkus, 2007; Visschers et al., 2009 for reviews of this literature). Some authors, therefore, suggest using graphical representations of numerical information for purposes of medical risk communication (Edwards, Elwyn & Mulley, 2002; Stallings & Paling, 2001; Visschers et al., 2009). There are studies within the medical field indicating that certain graphical risk communication formats are indeed better understood than numerical information (Waters, Weinstein, Colditz & Emmons, 2006; Woloshin, Schwartz, Byram, Fischhoff & Welch, 2000). However, this effect has not always been observed and seems to depend on the type of graph and the task at hand (Feldman-Stewart, Kocovski, McConnell, Brundage & Mackillop, 2000; Siegrist et al., 2008b; Weinstein, Sandman & Hallman, 1994).

Basically, there are two ways to depict the probability of a risk graphically. Either the risk is presented on its own (e.g., with an array of pictograms, see Siegrist et al., 2008b) or is related to other risks to put it into a broader context. The latter type of risk depiction might be especially helpful to convey risk information, as people intuitively seem to draw on analogies and risk comparisons to attach meaning to different risks (Bostrom, 2008; see also Visschers, Meertens, Passchier & De Vries, 2007). One special type of graph used to depict a target risk in relation to others consists of the so-called risk ladders. In these graphs, several risks are presented in an ascending order according to the level of risk to show where the target risk is located. Such risk ladders are often investigated in the field of environmental risks (Connelly & Knuth, 1998; Sandman, Weinstein & Miller, 1994). For medical contexts, a special type of risk ladder called the Paling perspective scale (PPS) was designed to help doctors communicate risks to patients (Paling, 2003; Stallings & Paling, 2001). This graph consists of a panel that is subdivided into sections according to a logarithmic scale. The target risk and several reference risks can be depicted in this panel without explicitly referring to numeric values. Thus, the PPS offers two advantages: first, a target risk can be related to reference risks, and second, due to the logarithmic scale, risks of very different probabilities can be depicted and compared.

To our knowledge, no previous studies have explored whether these two characteristics of the PPS really do play a role in how people look at a risk that is presented in this graph. Therefore, the first aim of our study is to investigate whether people pay attention to the reference risks while looking at the PPS and how they perceive the logarithmic scale.

To measure the perception of the graph as directly as possible, we used an eye tracker. This instrument follows a person's gaze and records eye movement data. Based on the presumption that the point of visual attention is also the focus of current cognitive processing (Just & Carpenter, 1976), eye movement data have been used to investigate the processing of visual displays, such as print advertisements (Rayner, Miller & Rotello, 2008), information graphics in newspapers (Holsanova, Holmberg & Holmqvist, 2009) and various types of graphs (Carpenter & Shah, 1998; Korner, 2004; Ratwani et al., 2008).

Numeracy

People's numeracy skills, which describe the ability to handle numbers, seem to affect the understanding of risk information (Apter et al., 2008; Nelson et al., 2008; Peters, Hibbard, Slovic & Dieckmann, 2007; Reyna & Brainerd, 2007). Low numeracy skills appear to be associated with greater difficulties in understanding risk information and being more prone to influences by framing effects (Peters & Levin, 2008; Peters, Vastfjall, Slovic, Mertz, Mazzocco & Dickert, 2006; Schwartz et al., 1997). Graphical risk presentations have been recommended, therefore, especially for persons with low numeracy skills (Apter et al., 2008; Nelson et al., 2008). Only a few studies, however, have examined whether persons with low numeracy skills are better able to understand risk depicted graphically compared to risk depicted numerically. A recent study found that persons scoring low on a numeracy measure were unable to differentiate between high- and low-probability risks when presented in the PPS, whereas persons scoring high on this numeracy measure were able to do so (Keller &

Siegrist, 2009). As visual attention is a prerequisite for understanding a graph (see, e.g., the framework presented by Grunert & Wills, 2007), the second aim of our study is to use eye movement data to investigate whether there is a relationship between numeracy skills and the visual perception of the PPS.

There are two mechanisms that can explain the relationship between understanding information depicted in a risk communication graph and numeracy. First, it is possible that graph reading, overall, is more difficult and complex for persons with low numeracy skills, as graph reading is part of numeracy itself. Studies about the comprehension of graphical displays in non-medical fields have shown that more complex graphs provoke more and longer fixations than simpler graphs due to more extensive cognitive processing involved in their interpretation (Carpenter & Shah, 1998; Ratwani et al., 2008; Renshaw et al., 2004). Therefore, we expect a negative relationship between the participants' numeracy and the total time needed to look at the risk communication graph as well as the total number of gazes (Hypothesis 1).

Secondly, there is some evidence indicating that persons with high numeracy skills integrate more information in the decision making process than persons with low numeracy skills (Peters & Levin, 2008). Applied to the visual perception of the PPS, this could imply that persons with high numeracy skills extract more information from the graph than persons with low numeracy skills and, thus understand it better. This mechanism, in turn, can be described as having higher efficiency with which they process the PPS. Goldberg and Kotval (1999) suggest that, in search tasks, higher ratios of fixations on target regions of a graph per total number of fixations are indicative of search efficiency. We therefore expect a positive relationship between the participants' numeracy and the number of elements of the PPS they consider relative to the total number of gazes (Hypothesis 2).

Rationale of the study

In sum, this study has two general purposes. First, the general aim is to find out how people look at the PPS, in order to find out whether they actually take into account the special characteristics of the graph that are designed to foster comprehension of the depicted risk. Second, we want to explore the association between numeracy and visual attention to the PPS.

Methods

Participants

Participants (N = 52) were invited from a pool of persons who had taken part in a recent study and who had agreed to participate in the present study. They were chosen based on their numeracy value, which had been measured in the earlier study, so that a wide range of numeracy values could be represented in our sample. An independent person selected the participants based on their numeracy scores. Another person, who was blind to the potential participants' numeracy value, contacted them by telephone. Five datasets could not be analysed due to bad eye tracking data quality (e.g. because of more than 20% missing data or strong offsets of eye movement measurements) and were excluded from further analysis. Thus, the sample used in the present study consisted of 47 participants: 15 females (32%) and 32 males (68%). The mean age was 51.5 years (SD = 13.4), and the education level ranged from lower-secondary school (8%, n = 4), upper-secondary vocational school (32%, n = 15) and upper-secondary school (11%, n = 5) to university/technical university (49%, n = 23). The participants received CHF 100 (approximately EUR 70) for their participation.

Materials

Informed consent

All the participants were asked to sign an informed consent form on which they indicated that the function of the eye tracker had been explained to them, that they allowed us to analyse their data, which would be done anonymously, and that they could stop their participation in this study at any time.

Numeracy

Numeracy was measured with the subjective numeracy scale (SNS; Fagerlin, Zikmund-Fisher, Ubel, Jankovic, Derry & Smith, 2007; Zikmund-Fisher, Smith, Ubel & Fagerlin, 2007b). This instrument consisted of an eight-item questionnaire about one's perceived numerical ability in several contexts (e.g. working with fractions, percentages or calculating a 15% tip). The average of all eight items resulted in the numeracy score. We chose the SNS because subjective numeracy in a broader sense could be interpreted as a special type of self-efficacy (Bandura, 1997) with regard to the handling of numbers. In some studies, self-efficacy measures have been shown to be relevant to information-seeking behaviours (Bass, Ruzek, Gordon, Fleisher, McKeown-Conn & Moore, 2006; Hong, 2006; Satia, Galanko &

Neuhouser, 2005). As looking for information in a graph like the PPS can be understood as information-seeking behaviour, the SNS seems to be the best instrument for this study because it provides information about both the ability and the self-efficacy aspects of numeracy.

Scenario and risk information

We used a risk scenario about prenatal screening, which we presented as slides on a 15.4″ monitor of a laptop computer. The hypothetical story on the first slide was about a 35-year-old woman ('Sandra'), pregnant with her first child, who had her blood tested for the probability of her unborn child having Down syndrome. The result of this test consisted of the probability that the child would be affected. This probability (1 in 112) was depicted graphically in a modified version of the PPS on the second slide (Figure 2.1.1; modified after Keller and Siegrist (2009), Stallings and Paling (2001)). We presented two reference risks in the graph: Down syndrome in women of Sandra's age (1 in 365) as well as Down syndrome in the general population (1 in 680). The actual numbers were not explicitly mentioned in the graph. They were only graphically depicted as data points and had to be derived by the participants using the logarithmic scale.

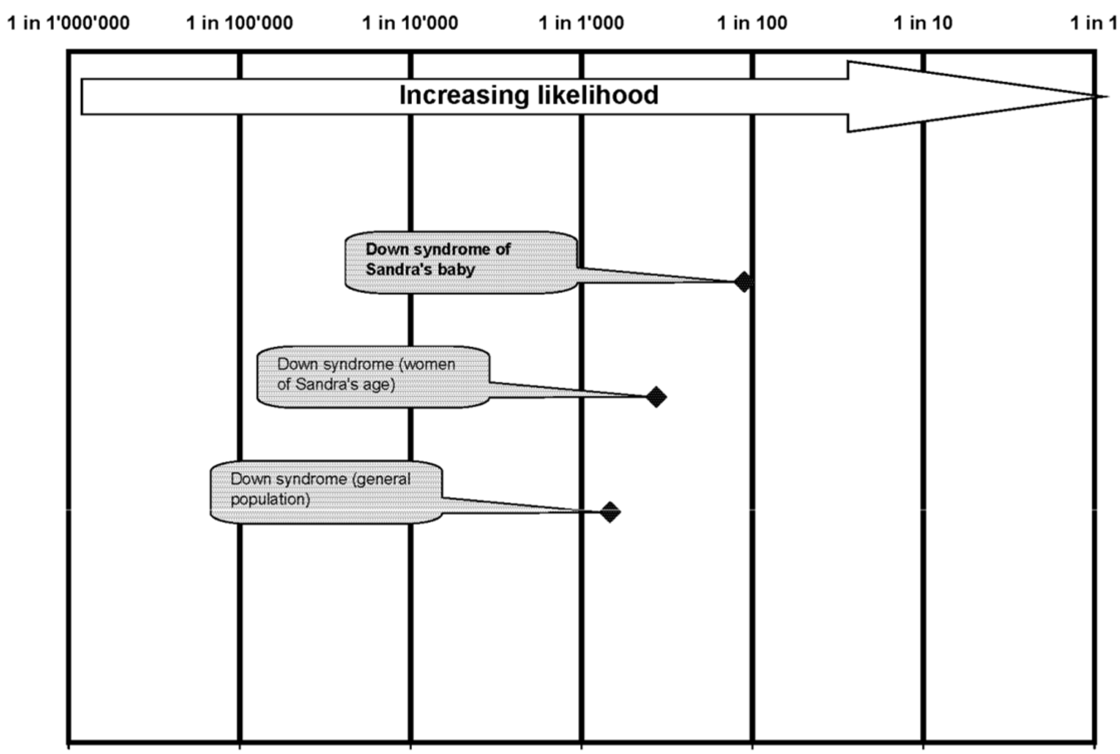

Figure 2.1.1. Modified Paling Perspective Scale; from Keller and Siegrist (2009), modified after Stallings and Paling (2001)

Above and below the graph, we presented textual information. Above the graph, there was a short text instructing the participants to keep in mind the level of the depicted risk and the emotions caused by the depicted risk. Below the graph, there was information about how to proceed to the next slide.

Eye tracker

We used a 50-Hz SMI HED4 eye tracker to measure people's visual attention. This is a dual-Purkinje dark pupil eye tracker system consisting of two cameras on a helmet, which the participant wears on the head. The scene camera records the scene a person is looking at (25 pictures per second). The eye camera films the eye itself (50 pictures per second). The data from both cameras are transmitted to a computer, which measures the centre of the pupil as well as Purkinje light reflections. Special software calculates the gaze direction and location based on these parameters. These are then presented in the scene video, whereby the gaze is depicted as a small circle in the scene.

Procedure

The study took place in a laboratory with constant light. First of all, the eye tracker was explained, and all the participants provided written informed consent. Then, the experimenter installed and calibrated the eye tracker. Calibration was checked and, if necessary, repeated.

The participants were then shown an exercise scenario about the risk of malaria infection while travelling (depicted in a pie chart). This scenario enabled the participants to get used to the eye tracker and to the type of task, and was not analysed. The eye tracker was re-calibrated, and then the Down syndrome scenario described above was shown. The eye tracker recorded the eye movements for as long as respondents perceived the graph; there was no time limit. The participants then assessed their emotional response to the depicted risk (on a scale from 0, very negative, to 100, very positive) and the level of the depicted probability (on a scale from 1, very low, to 6, very high). These questions and the instructions focusing on the presented risk and emotions were intended to stimulate the respondents' evaluation of the presented risk. At the end of the session, the participants provided the demographic information (gender, age, education), and the subjective numeracy was measured with the SNS (Fagerlin et al., 2007; Zikmund-Fisher et al., 2007b).

Data analysis

This procedure resulted in 47 videos of the PPS with overlaid gazes (in the form of a moving red circle called the 'gaze cursor'), which were coded by using video-coding software (Interact, version 8.4.4, Mangold International). Prior to the analysis, the PPS was subdivided into 22 so-called areas of interest (AOI), which were defined as regions in and around the graph that one could look at while watching and interpreting the PPS (see Figure 2.1.2).[1] We assigned a code to each AOI.

A code was assigned to an AOI if the gaze stayed on an AOI for at least three video pictures (120 ms). This time threshold was chosen because it approximately equaled the minimum time span of the fixation (see Salvucci & Anderson, 2001). Each such time period of at least 120 ms within one AOI was called a 'gaze event'. From these gaze events, we calculated two types of gaze variables: cumulative duration of gazes in each AOI (in seconds) and frequency of gaze events in each AOI. Thus, the gaze duration variables provided information about how long participants looked at each AOI while they processed the graph, irrespective of how often they looked at this AOI. Gaze frequency variables, on the other hand, showed how many times respondents looked at the AOIs, irrespective of how long they did this.

To track gaze patterns between AOIs in the PPS, we also analysed certain sequences that were necessary to understand the graph. These crucial sequences consisted of all three risk information AOIs (indicating people's understanding of the nature of the risks in question), the corresponding data points (understanding of the position of the risks in question), the Scales 4 and 5 (understanding of the probability of the risks in question), and the Scales 3 and 6 (understanding of the logarithmic scale). The sequences were calculated as pairs of these AOIs that were looked at one after the other (in terms of frequencies of each sequence). For example, when someone looked first at Data Point 1 and then at Scale 5, this was coded as sequence DataPoint 1/Scale 5 with a frequency of 1.

Our analyses showed that all line AOIs as well as the AOI 'scale undefined' were looked at very rarely. Therefore, we did not report any results related to these AOIs. The texts above and below the graph were coded as text variables. Missing information was coded when the gaze cursor was not visible for more than eight video pictures (320 ms, not in order to overrate blinks that should be shorter than this duration, see Caffier, Erdmann & Ullsperger, 2003), or if the gaze cursor was visible but absolutely not interpretable for at least three video

[1]Not shown in Figure 2.1.2 is an AOI labelled 'scale undefined', which means that the gaze is somewhere on the scale, but not clearly focused on one of the scale points.

pictures (120 ms, e.g. due to strong head movements). The videos contained, on average, 6% missing data (*SD* = 4%).

Fourteen videos were rated by an independent second rater. Based on the codes of each rater, we calculated gaze durations, gaze frequencies and sequences of these 14 participants for all AOIs (except lines and scale undefined), as well as for total variables (total duration, total number of gaze events, total number of AOIs considered). Pearson correlations were computed between the two ratings of these variables to assess the inter-rater reliability. This resulted in the very high average correlation coefficients for the duration variables (M_r = 0.97), the frequency variables (M_r = 0.93) and the sequence variables (M_r = 0.85). Both raters were blind to the participants' numeracy values in order to avoid over- or under-rating of certain AOIs.

Data analysis was conducted with SPSS (version 16.0.1, SPSS Inc.) and SYSTAT (version 12.00.08, SYSTAT Software Inc.). As gaze variables partially showed outliers and were not normally distributed, medians and 95% confidence intervals (CIs) of the medians were reported. These CIs were calculated with bootstrapping (Efron & Tibshirani, 1993; Mooney & Duval, 1993). With this procedure, the sample was considered as a population from which many random samples were drawn (with replacement). The median was then calculated for all of these hypothetical samples. The CI of the observed median could, in turn, be derived from these bootstrapped medians. We chose 1000 samples of 47 units each for this procedure. The associations between the different gaze variables and subjective numeracy were examined with Spearman rank correlations.

Results

Overall description of visual attention to the PPS

As we were interested in the perception of the graph and not in the processing of text, all subsequent analyses referred to the perception of the PPS without instructional text. The participants looked at the PPS for a median duration of 28.4 s (95% 22.2, 30.5 s). The median number of gaze events for looking at the PPS was 37 (95% CI 31, 43). The participants looked at 14 (*Mdn*; 95% CI 13, 15) of the 22 AOIs within the PPS. On average, the participants assessed the target risk depicted in the PPS (1 in 112) as rather high (*M* = 3.9, *SD* = 1.1; scale 1–6) and associated it with negative feelings (*M* = 21.2, *SD* = 12.9; scale 0–100).

Figure 2.1.2 shows how long the participants look at the various parts of the graph. Medians and CIs for gaze duration and gaze frequency are shown in Table 2.1.1. Results showed that the participants spent the most time looking at Risk Informations 1 and 2, whereas they spent significantly less time on Risk Information 3. Most participants looked at all three data points. In other words, they looked at the information that was needed to make risk comparisons. However, there were differences within the gaze durations of the three points. Data Point 1 was looked at for the longest, followed by Data Point 2 and Data Point 3. Results further suggested that the participants focused more on Scales 4 and 5 than on the other scale points.

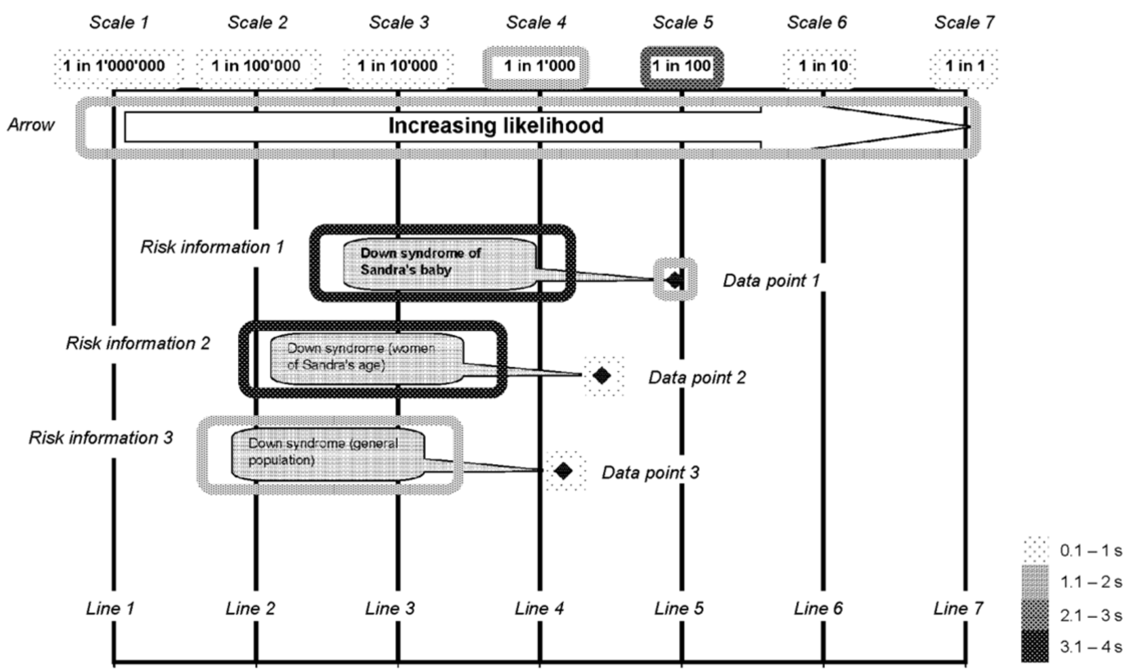

Figure 2.1.2. Duration of gazes in different AOIs (median values; the darker the pattern, the longer the gazes; all AOIs that were looked at for less than 0.1 seconds are not marked; names of AOIs in italics)

Overall results of gaze duration and gaze frequency were very similar. Both suggested that the participants looked longer and more often at the parts of the graph that were important for understanding the target risk information, and that they looked for less time and less frequently at the areas that were less important. Furthermore, there seemed to be a decrease in attention from Risk Information 1/Data Point 1 (the target risk to be communicated), as well as Risk Information 2/Data Point 2 (the first reference information), to Risk Information 3/Data Point 3 (the second reference information).

In addition to the duration and the frequency of gazes in different AOIs, the frequency of gaze sequences between certain areas can shed light on the visual attention to the graph.

Figure 2.1.3 shows the distribution of such sequences that are important for the understanding of the graph and appear with at least a median frequency of 1. The most frequent sequences are the ones between Risk Information 1 and Data Point 1, as well as between Data Point 1 and Scale 5. In addition, there seems to be a concentration on the target risk to be communicated in the first place. This is observable in regard to the sequences between the reference risk information and the corresponding data points. Again, these results reflect a greater visual attention to these important parts of the graph. However, it becomes clear that the participants might not have made all the risk comparisons that the graph offers. The results suggest that they compared Data Point 1 directly with Data Point 2, and Data Point 2 directly with Data Point 3. On the other hand, they probably did not make the direct comparison between Data Point 1 and Data Point 3 (*Mdn* = 0, 95% CI 0, 0). The same is true for the comparisons between the risk information AOIs. The sequence analysis indicates that the participants focused on the understanding of the target risk (Risk Information 1, Data Point 1, and Scale 5) and paid less attention to the other information presented in the graph.

Table 2.1.1. Medians and 95% confidence intervals of gaze durations (cumulated, in seconds) and of gaze frequencies, *N* = 47

	Gaze duration		Gaze frequency	
Variable	Median	CI (95%)	Median	CI (95%)
Scale 1	0.8	0.5 - 1.4	1	1 - 2
Scale 2	0.2	0.2 - 0.5	1	1 - 1
Scale 3	0.4	0.3 - 0.7	1	1 - 2
Scale 4	1.4	1.1 - 2.3	3	3 - 4
Scale 5	2.2	1.5 - 2.8	4	3 - 5
Scale 6	0.4	0.3 - 0.7	1	1 - 2
Scale 7	0.4	0.3 - 0.6	1	1 - 1
Arrow	1.5	1.1 - 1.9	2	2 - 3
Risk information 1	3.3	2.7 - 4.2	5	4 - 5
Risk information 2	3.2	2.7 - 4.7	2	2 - 3
Risk information 3	2.0	1.4 - 2.6	2	1 - 2
Data point 1	1.2	0.8 - 1.7	4	4 - 5
Data point 2	0.6	0.6 - 0.8	2	2 - 3
Data point 3	0.4	0.4 - 0.6	2	1 - 2

Note: Confidence intervals were calculated with bootstrapping by using the percentile method (see Efron & Tibshirani, 1993)

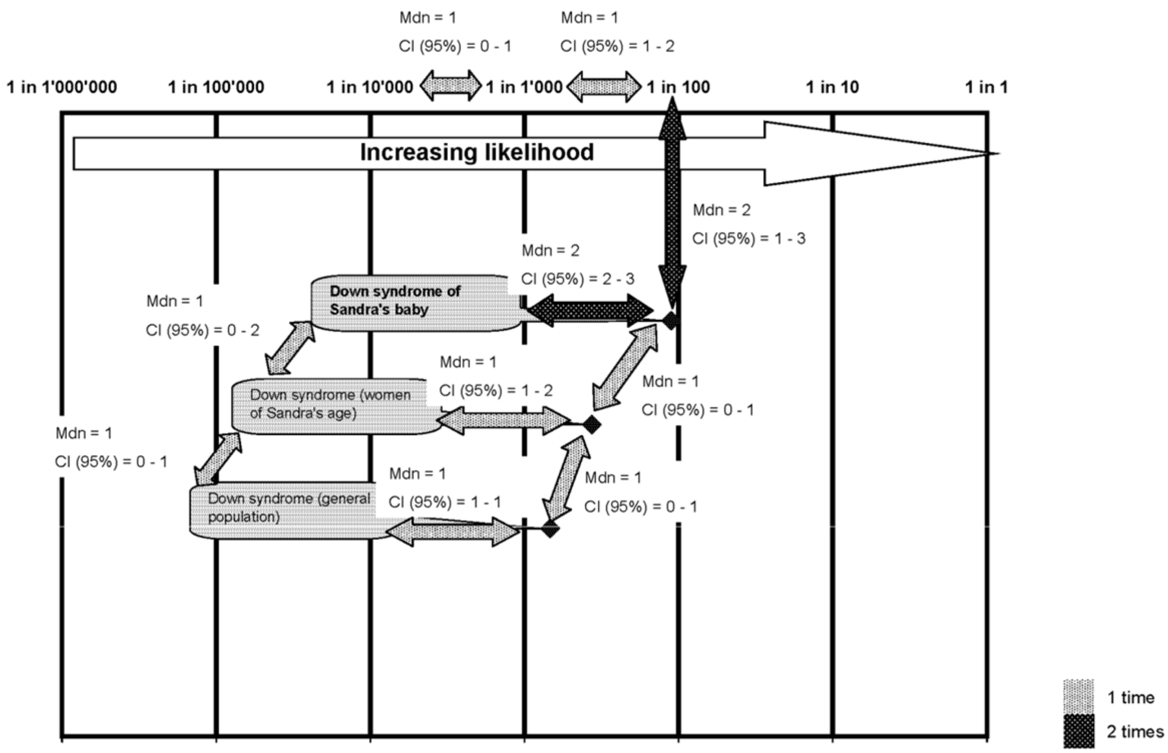

Figure 2.1.3. Frequencies of gaze sequences between important AOIs (median values; the darker the pattern, the more often the sequence occurred; all sequences that occurred less than once are not marked)

In sum, the analysis of the overall visual attention to the PPS indicated that the participants focused on the parts of the PPS that were most relevant to the understanding of the target risk information. They paid less attention to the elements that were less important to make such an evaluation. Results further suggested that the participants paid more attention to Risk 2 than to Risk 3, and that they probably only compared the adjacent risk information AOIs.

Correlations between visual attention and subjective numeracy

Mean subjective numeracy was 4.4 (SD = 0.7) on a scale from 1 to 6. The eight items of the scale showed good internal consistency (Cronbach's α = 0.81). To explore the relationship between visual attention to the PPS and subjective numeracy, we calculated rank correlations between the subjective numeracy and the total duration, the number of gaze events and the number of AOIs that were considered.

There was a significant negative correlation between the subjective numeracy and the time spent looking at the PPS ($r_S = -0.37$, $p = 0.01$), as well as between the subjective numeracy and the total number of gaze events ($r_S = -0.32$, $p = 0.03$). Results thus suggested that the participants with lower subjective numeracy needed more time and more gaze events to extract information from the graph. The absolute number of AOIs that the participants looked at was not significantly correlated with subjective numeracy (r_S = −0.20, ns). We computed a relative version of this variable, in which the number of AOIs that were totally considered was related to the total number of gaze events. Higher values of this relative variable indicated that fewer gaze events were needed to look at the considered AOIs, whereas lower values indicated that more gaze events were necessary to take the considered AOIs into account. Thus, this variable measured a kind of efficiency with which the graph was looked at. This relative variable was positively correlated with subjective numeracy (r_S = 0.34, p = 0.02). These results indicated that the lower subjective numeracy was associated with a longer period of time that was spent looking at the graph and more switching between the AOIs. On the other hand, higher subjective numeracy was related to more efficient processing of the PPS because less time and fewer gaze events were needed to take into account a similar number of elements in the graph.

Discussion

Overall visual attention to the PPS

The first aim of this study is to find out how people look at a risk communication graph in which a risk is placed in the context of other risks. Results show that participants focus on the parts of the graph that are important for the understanding of the target risk information. This shows that it was basically clear for the participants where the information that had to be extracted could be found in the graph. Furthermore, risk ladders provide reference risk information. Our results showed that many participants did look at all three risk information areas. However, they paid less attention to the third risk information area, and they might not have directly compared all three risk information areas. Participants most often compared the target risk information with the adjacent one but not with the second reference risk. There were two explanations for this concentration on the first reference risk. On the one hand, the mere fact that the second reference risk was spatially further away could have led to less attention to this information. On the other hand, the first reference risk provided information about a population similar to that of the target risk. This similarity could have increased the perceived relevance of the first reference risk and, therefore, might have led to increased attention to this information. These results may imply that people, when they were looking at the PPS, did not use the full potential for risk comparisons that this graph actually offered them. Instead, they seemed to focus on the target risk information and its comparison with the reference risk that was spatially closest and/or most similar.

In regard to the logarithmic scale, the participants focused on Scales 4 and 5. One reason for this result was probably the fact that the data points of the three risks were located between these two scale points. Participants had to compare the data points to the corresponding scale points to get an impression of the probabilities of the depicted risks. The remaining scale points were looked at only once and only for a very short time period. As the meaning of a logarithmic scale might not be intuitively easy to understand, we would expect that at least the scale points adjacent to Scales 4 and 5 would be looked at for longer and more often to integrate the meaning of the scale (for the association between longer and more frequent gazes and processing of a graph, see Renshaw et al., 2004). This was not the case in our sample. It cannot be excluded, therefore, that some participants mistakenly perceived the distance between Scale 4 and Scale 5 not as logarithmic but as linear. Thus, further studies are needed to investigate the understanding of the logarithmic scale.

Our results suggest that two points should be considered when designing risk ladders for graphical risk communication. First, spatial closeness and/or similarity seem to influence which risk comparisons people make in a graphically depicted risk ladder. It is thus crucial for graph designers to choose this reference risk with care and according to the task at hand. Second, our study gives a preliminary suggestion that a logarithmic scale might not be the best choice for a risk communication graph. If the risks depicted in a risk ladder do not vary too much in probability, the comprehension of the graph might be enhanced if a linear scale is used.

Correlations between visual attention and subjective numeracy

The second aim of this study is to find out whether there is a relationship between visual attention to the PPS and subjective numeracy. Overall, lower subjective numeracy is associated with longer total gaze duration and with more gaze events. These results may suggest that it is more difficult for persons with lower subjective numeracy than for persons with higher subjective numeracy to understand the graph and extract information from it (for the association between longer and more frequent gazes and processing of a graph, see Carpenter & Shah, 1998; Ratwani et al., 2008; Renshaw et al., 2004). This finding is in line with our first hypothesis. Furthermore, subjective numeracy is positively correlated with the relative values of number of considered AOIs. Thus, participants with higher subjective numeracy look at about the same number of elements in a shorter amount of time than participants with lower subjective numeracy. According to Goldberg and Kotval (1999), such relative measures are an indication of higher search efficiency. Thus, this result supports our second hypothesis and adds to the assumptions from Peters and Levin (2008), who suggest that individuals with higher numeracy manage to integrate more information in their decision making processes than persons with lower numeracy. Our results imply that this mechanism can be due to the efficiency of this integration process.

All in all, participants with lower subjective numeracy seem to have problems extracting and integrating information from the PPS. Thus, our results suggest that graphs might not be easy to process per se and should be customized to simplify the information integration process for persons with lower numeracy. This finding might be of crucial relevance to risk communication, as graphical displays are considered to be less complex than numbers and are therefore recommended for risk communication with persons of higher age or low numeracy (see, e.g., Finucane, 2008). It can also explain why participants with lower numeracy in Keller and Siegrist's study (2009) are not able to differentiate between high and low risks when these risks are depicted in the PPS.

However, the modification of graphs alone might not be enough to enhance the understanding of risk communication graphs. The situation in the laboratory, with the eye tracker on the head of the participant and a researcher in the same room who could see where participants were looking, was probably highly motivating for all participants to gaze at the graph until they had looked at most parts of it. In some situations, such an external motivation may be present, for example a medical doctor who presents such a graph and emphasizes the importance of understanding the presented probability. In other everyday situations, however, this kind of motivation might not be present. It is an open question whether people would then also take the same time and effort to look at a risk communication graph in the absence of external motivation. There are indications that information seeking behaviour is positively associated with context-specific self-efficacy (Bass et al., 2006; Hong, 2006; Satia et al., 2005). It is, therefore, possible that, in some real-world situations, people with lower subjective numeracy look for less information in graphs because of their lower self-efficacy in understanding the numerical risk information depicted in these graphs. This mechanism might also lead to differences between persons with high and low numeracy in understanding risk information depicted in graphs as observed by Keller and Siegrist (2009). If this was the case, the modification of the graph alone would not enhance risk communication efforts, as the crucial element would not be the understanding of the graph but the attention that was paid to the graph.

In addition, one should keep in mind that we used hypothetical scenarios that focused on the processing of graphically depicted information and that did not include decision making based on this information. In reality, however, such graphs would be used in situations that could have severe medical implications for the patients showing them. These special situations might influence the processing of risk graphs in many ways that we could not observe in this study. Worry about cancer, for example, has been found to be associated with more attention to health information (Beckjord, Rutten, Arora, Moser & Hesse, 2008). On the other hand, seeking information about medical conditions might be inhibited by negative affect when one has the feeling of less control over one's health (Lee, Hwang, Hawkins & Pingree, 2008).

In short, future studies are needed to show whether the skills used to extract information from a graph, as well as the complexity of the graph, the external motivation or an interaction of these factors influence the understanding of graphically depicted risks. Moreover, the role of specific aspects of real decision making situations should be examined, such as motivating or inhibiting factors interplaying with numeracy in the processing of graphically depicted risks.

Limitations

This study has several limitations. First, we recruited our sample in a way to ensure a broad range of subjective numeracy. This led to some biases concerning other variables. The sample included more men than women, and the mean age as well as the mean level of education was rather high. Thus, the results may not be easily generalized to other populations and should first be verified in other samples. Second, there were some limitations related to the eye tracking data. We used a mobile eye tracker that could not give exact fixations due to movements of the head. Therefore, our data consisted of manually coded cumulative gaze duration and frequency variables. The studies on which we based our interpretations, on the other hand, usually took fixations or even saccades as units of measurement (Carpenter & Shah, 1998; Goldberg & Kotval, 1999; Ratwani et al., 2008; Renshaw et al., 2004). Furthermore, these previous studies were conducted on search tasks or on usability testing of computer interfaces. Thus, it was not perfectly clear whether these findings could be transferred one-to-one to gaze event data such as ours. Given these limitations, we tried to apply the interpretational framework with care to prevent overinterpretation of our data.

Conclusion

The results of the present study suggest that an eye tracker is a useful tool for evaluating the perception of graphical risk communication, as it can indicate which information receives visual attention and, thus, which may be easily processed. The present research also demonstrates that an eye tracker can be successfully used for examining individual differences. Higher subjective numeracy seems to be related to more efficient processing of the PPS. This result suggests that graphical risk communication, which some scholars explicitly recommend for persons with lower numeracy (Apter et al., 2008; Nelson et al., 2008), should be further improved to address the needs of these persons. Our findings imply that the reference information, and maybe also the logarithmic scale, can be starting points for the modification of the PPS. These implications can be of use in contexts other than medical risk communication (e.g. for environmental risks, where risk ladders are also common, see Connelly & Knuth, 1998; Sandman et al., 1994), which is important for findings in risk research more generally (Loefstedt & Six, 2008).

Chapter 2.2
Risk communication with pictographs: The role of numeracy and graph processing

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Abstract

We conducted three studies to investigate how well pictographs communicate medical screening information to persons with higher and lower numeracy skills. In Study 1, we conducted a 2 (probability level: higher vs. lower) x 2 (reference information: yes vs. no) x 2 (subjective numeracy: higher vs. lower) between-subjects design. Persons with higher numeracy skills were influenced by probability level but not by reference information. Persons with lower numeracy tended to differentiate between a higher and a lower probability when there was no reference information. Study 2 consisted of interviews about the mental processing of pictographs. Higher numeracy was associated with counting the icons and relying on numbers depicted in the graph. Study 3 was an experiment with the same design as in Study 1, but, rather than using reference information, we varied the sequence of task type (counting first vs. non-counting first) to explore the role of the focus on numerical information. Persons with lower numeracy differentiated between higher and lower risk only when they were in the non-counting first condition. Task sequence did not influence the risk perceptions of persons with higher numeracy. In sum, our results suggest that pictographs may be useful for persons with higher and lower numeracy. However, these groups seem to process the graph differently. Persons with higher numeracy rely more on the numerical information depicted in the graph, whereas persons with lower numeracy seem to be confused when they are guided towards these numbers.

Introduction

Patients are often confronted with difficult medical decisions. Many of these decisions have to be made based on numerical information (e.g., information about chances and risks of treatment, see Lipkus, Peters, Kimmick, Liotcheva & Marcom, 2010). Therefore, it is quite important that this information is understood correctly. Past research has shown that many people have difficulties understanding numerical risk information (Gigerenzer & Edwards, 2003; Visschers et al., 2009), and that persons with low numeracy skills (the ability to understand numbers) are especially challenged by numerical information (Lipkus & Peters, 2009; Peters, 2008). Therefore, not surprisingly, more and more studies show that low numeracy is associated with less understanding of medical information and unfavorable decision outcomes (see, e.g., Donelle, Arocha & Hoffman-Goetz, 2008; Schwartz et al., 1997; Tanius et al., 2009; Zikmund-Fisher et al., 2008b).

Different solutions have been proposed for improving the communication of medical information. Some authors suggest, for example, that numbers should be expressed as frequencies (Gigerenzer & Edwards, 2003; Hoffrage et al., 2000) or, especially for persons with low numeracy, conveyed in graphs (Apter et al., 2008; Nelson et al., 2008). One special type of graph combines these two recommendations for risk communication because the graph a) shows frequency information, and b) conveys numbers in a purely graphical way. These so-called pictographs show the number of people affected by a certain medical condition in a larger group of people (i.e., the denominator of mostly 100 or 1000, see Figure 2.2.1; for other examples of this type of graph, see also Edwards et al., 2002; Paling, 2003; Schapira, Nattinger & McHorney, 2001). Therefore, this type of graph seems to be a promising tool for communicating medical information to persons with low numeracy.

Several studies show that pictographs help people with low numeracy understand medical information (Galesic et al., 2009; Hawley et al., 2008; Zikmund-Fisher et al., 2008a). However, although pictographs seem to improve low-numerates' direct understanding of the presented numbers (e.g., knowledge of how many persons are affected by a certain disease), it is not yet clear how this graph influences low-numerates' risk perception. The influence of pictographs on risk perception, however, may be crucial because perceiving a risk as either high or low might have a greater impact on behavioural intentions than understanding the numerical information alone (Zikmund-Fisher, Fagerlin, Keeton & Ubel, 2007a).

Generally, pictographs seem to evoke lower risk perceptions than other presentation formats, such as the Paling perspective scale (Paling, 2003) or numerical frequencies (Galesic et al., 2009; Keller & Siegrist, 2009; Siegrist et al., 2008b). Unfortunately, it is not possible to decide whether a reported risk perception is the 'correct' one, because it is subjective in nature. To handle this difficulty, one can conduct an experiment to investigate whether different levels of probabilities evoke different levels of perceived risk (Keller & Siegrist, 2009; Siegrist et al., 2008b). In this approach, participants are faced with either a higher or lower probability, and then estimate their perceived risk. We then analyse the extent to which participants confronted with the higher risk perceive the risk as higher than participants confronted with the lower risk. Results of two previous studies following this procedure using pictographs showed that a higher probability did not evoke a higher level of perceived risk than a lower probability (Keller & Siegrist, 2009; Siegrist et al., 2008b). This result might suggest that, although some studies showed that pictographs seem to help persons with low numeracy to understand the numbers depicted in a graph, pictographs may not help them to evolve clearly distinguishable risk perceptions to the same degree. Thus, the type of task used in a study may influence the evaluation of pictographs. The role of numeracy in this perception process is, to our knowledge, not yet fully understood. We therefore conducted three studies to examine the influence of numeracy on people's perceptions and, as a new approach to this question, on people's processing of numerical medical information depicted in pictographs. To examine this issue, we chose the context of cancer screening test results, as some studies have shown that numeracy is important in this area (Donelle et al., 2008; Hanoch, Miron-Shatz & Himmelstein, 2010; Schwartz et al., 1997).

Numeracy is defined as a person's ability to understand and process numerical concepts (see e.g., Peters, 2008). It can be measured in two different ways. Objective measures assess people's numeracy by letting them solve mathematical tasks (Lipkus, Samsa & Rimer, 2001; Schwartz et al., 1997). One problem with using such objective measures in mail-in surveys is that the respondents might use helping devices such as calculators. This would then bias the resulting numeracy score. Furthermore, respondents might find it annoying to fill in such questionnaires and, thus, might simply avoid them when they have the opportunity to do so (Fagerlin et al., 2007). To cope with this problem, Fagerlin and colleagues (2007) developed the subjective numeracy scale, which assesses self-reported numeracy skills. This measure offers the advantage of shorter administration and less reluctance from participants than objective measures (Fagerlin et al., 2007). On the other hand, this measure relies entirely on self-reported numerical ability and preference. Moreover, although it is positively correlated with objective numeracy (Fagerlin et al., 2007), it does not measure exactly the same construct as the direct measurement of mathematical skills in objective numeracy measures.

In short, the aim of our first study was to examine the influence of subjective numeracy on the perception of cancer screening test results presented in pictographs. Following Siegrist and Keller's approach (Keller & Siegrist, 2009; Siegrist et al., 2008b), we conducted an experiment to examine whether different levels of probabilities evoke different levels of perceived risk. To reach a deeper understanding into how pictographs might influence risk perception in relation to numeracy, we conducted a second study. We thereby directly examined the processing of cancer screening results depicted in pictographs and its association with numeracy. Finally, in Study 3, we explored the role of the sequence of the task (numerical understanding first vs. risk perception first) in the context of risk communication with pictographs and numeracy. With this manifold procedure, we aim to broaden the existing knowledge about numeracy in medical decisions by investigating the role of numeracy in risk perception. We aim to accomplish this by revealing the underlying process that might lead to differences between persons with higher and lower numeracy.

Study 1

In a previous study, pictographs showing either a higher or a lower probability test result did not evoke corresponding higher or lower risk perceptions among participants with higher or among participants with lower numeracy (Keller & Siegrist, 2009). This finding could suggest that this type of graph does not evoke differentiated risk perceptions for different probability levels, irrespective of an individual's numeracy. However, several other possible explanations exist for the pictograph's lack of effect. Therefore, Study 1 aimed to rule out some of the possible factors that could have impeded the successful communication of different probability levels in this previous study (Keller & Siegrist, 2009). We investigated whether modified pictographs could evoke differentiating risk perceptions in persons with higher and lower numeracy.

First, the size of the denominator of a pictograph may influence risk perception and understanding of the information in the graph (Galesic et al., 2009; Zikmund-Fisher et al., 2008b). Keller and Siegrist (2009) used rather low risks depicted in pictographs with large denominators (1 in 1000, 9 in 1000, 21 in 1000, 167 in 1000). In a focus group study about the perception of different formats of risk communication, participants preferred pictographs with small denominators to pictographs with large denominators because the participants found the pictographs with small denominators easier to interpret (Schapira et al., 2001). The denominator in Keller and Siegrist's (2009) study may thus have been too large to efficiently depict such low risks because the large denominator of 1000 complicated the processing of the graphs. This might have made all of the risks seem equally low, even for persons with high numeracy. This mechanism could then have overshadowed a potentially beneficial effect of the pictographs. We therefore chose a smaller denominator in our study. More specifically, we aimed to investigate whether two levels of probability depicted in a pictograph of 100 icons led to different risk perceptions. We hypothesized that persons confronted with a higher probability would report a higher risk perception than when confronted with a lower probability (Hypothesis 1). We expected a similar effect for persons with higher and lower numeracy.

Another factor that may influence the decision of whether a given probability is high or low may be the absence of additional information that puts a risk in a broader context (see Lipkus, 2007). In everyday life, comparing one's own risks to those of others seems to be done automatically: when faced with test results in a medical context, people compare their personal test results to what is communicated to them as the normal value (Adelsward & Sachs, 1996). In a study by Dillard and colleagues (2006), providing women with reference information in the form of higher risks of other women helped them to avoid overrating their own breast cancer risk. Furthermore, graphical or numerical reference risk information seemed to enable people to differentiate between a higher and a lower risk (Siegrist et al., 2008b). Thus, in Keller and Siegrist's (2009) study, pictographs may have failed to convey the difference between higher and lower risk because of the lack of reference information. Adding reference information to the pictograph could therefore help to evoke a differentiating risk perception. Hence, we hypothesized that participants confronted with a higher probability would report higher risk perceptions compared with participants confronted with a lower probability when there is a second pictograph with reference information (Hypothesis 2). We expected to observe the same effect for persons with higher and lower numeracy.

Method Study 1

Participants and procedure

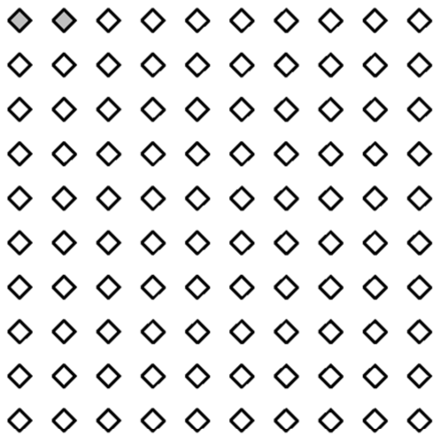
Study 1 was an experiment that was part of a survey about health and nutritional information. The topic of the experiment reported here was different from the survey's other content. Therefore, no carry-over effects were expected. The questionnaire was sent to a sample of households in the German-speaking part of Switzerland. The households were randomly chosen from the Swiss telephone book. In total, 589 questionnaires were returned, which resulted in a response rate of 38%. Of these 589 questionnaires, 56 were not completely filled in with regard to numeracy or the dependent variable of the experiment. Therefore, our analyses were based on the responses of 533 participants. Of the 533 participants, 296 (56%) were women; three persons did not specify their sex. Respondents were between 17 and 94 years old (M = 53.32 years, SD = 15.69). In our sample, 42 persons (8%) had finished primary or lower secondary school; 256 (48%), upper secondary vocational school; 79 (15%), upper secondary school; and 151 (28%), university/technical university. Five persons did not provide information about their educational level.

All respondents read the same hypothetical scenario about a woman ('Daniela') who had a screening test for colorectal cancer. The doctor used a personalized pictograph to inform her about the test results. This pictograph was shown in the questionnaire and consisted of an array of 100 icons (10x10) with grey and white icons, which represented the probability of Daniela having colon cancer and the probability that she did not have cancer, respectively see Figure 2.2.1). At the end of the scenario, all participants estimated the risk of Daniela having cancer on a 6-point scale (1 = very low probability to 6 = very high probability). This part of the procedure was the same for all participants.

Three factors were used for a 2 (probability level: higher vs. lower) x 2 (presence of reference information: yes vs. no) x 2 (subjective numeracy: higher vs. lower) between-subjects design. The level of the depicted probability for Daniela having colon cancer was either 17 in 100 (higher) or 2 in 100 (lower). Each participant thus saw either the lower- or higher-probability graph. This manipulation allowed us to analyse whether the participants' risk perceptions differed across the two levels. Furthermore, half of the participants saw only the graph for Daniela's probability (i.e., only the top half of Figure 2.2.1 consisting of the first text and the first graph), whereas the other half received reference information in the form of a second pictograph (see Figure 2.2.1). In this reference graph, we additionally depicted the average probability of a woman of the same age as Daniela having colon cancer (4 in 100). These manipulations resulted in four versions of the questionnaire, to which the participants were randomly assigned.

Please imagine the following hypothetical situation:

Daniela had a test at her general practitioner's. This test identifies the probability of the presence of colon cancer. As soon as the test results are available, the doctor informs Daniela by means of the following figure that was prepared especially for her. The grey dots represent the probability that Daniela has colon cancer, the white dots the probability that Daniela does not have colon cancer.



Additionally, the doctor shows Daniela a figure that highlights how high the average probability is for women in Daniela's age group. The grey dots again represent the probability of the presence of colon cancer.

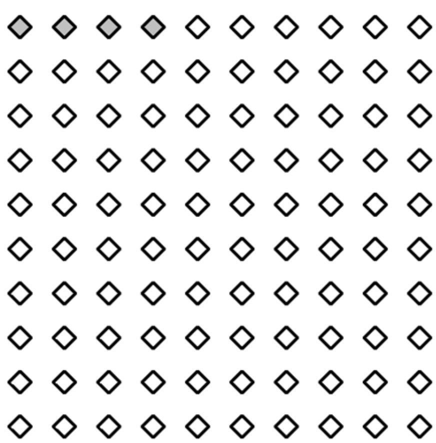


Figure 2.2.1. Example for one of the conditions (lower probability, reference information present) used in Study 1

Because Study 1 was a mail-in survey, we could not directly control whether the respondents used calculators and filled in all questions. Therefore, we used the subjective numeracy scale (SNS, Fagerlin et al., 2007) to measure the participants' numeracy. Another reason for using the SNS was that we assumed that more respondents would return the questionnaire with this scale than with an objective numeracy scale. The SNS is a self-reported measure of one's ability to handle numbers, as well as one's preference for numbers. The scale consists of 8 items (e.g., 'How good are you at working with percentages?' 'How often do you find numerical information to be useful?' assessed on 6-point scales) and results in an average numeracy score from 1 (low numeracy) to 6 (high numeracy).

Data analysis

To test whether probability level, reference information, and subjective numeracy influence risk perception, we utilized an analysis of variance (ANOVA). For ease of interpretation, we performed a median split on the subjective numeracy measure (higher vs. lower numeracy). However, as subjective numeracy is a continuous variable, we conducted an additional analysis of covariance (ANCOVA) with probability estimate as the dependent variable, the probability level and reference information as factors and subjective numeracy as a continuous covariate. All statistical analyses were performed with SPSS version 17.0 (SPSS, Inc.).

Results Study 1

Mean subjective numeracy was 4.17 (SD = .87, scale 1– 6); the internal consistency of the SNS was good (8 items; Cronbach's α = .82). We performed a median split on subjective numeracy (Mdn = 4.25), which resulted in a higher-numeracy group (n = 279) and a lower-numeracy group (n = 254).

The ANOVA showed that reference information did not play a significant role for risk perception, either as a main effect, $F(1, 525) = .25$, $p = .62$, or as an interaction effect with one or both of the other factors, $Fs \leq .89$, $ps, \geq .35$. We found significant main effects for probability level, $F(1, 525) = 20.82$, $p < .001$, as well as for subjective numeracy, $F(1, 525) = 4.66$, $p = .03$, and a significant interaction effect for probability level x subjective numeracy, $F(1, 525) = 4.82$, $p = .03$.

Table 2.2.1 shows the average risk perception for each of the eight cells of the experiment. Planned independent t-tests following Hypotheses 1 and 2 showed that persons with higher numeracy differentiated between the higher and the lower probability levels, irrespective of whether there was reference information or not (see Table 2.2.1). Although the interaction effects with reference information were non-significant, there was an interesting and rather counter-intuitive t-test result in the lower numeracy groups. When there was no reference information present, persons with lower numeracy seemed to differentiate between higher and lower probabilities. However, when there was a reference information graph, persons with lower numeracy who had seen the lower risk did not have different risk perceptions than persons with lower numeracy who had seen the higher risk (see Table 2.2.1).

Table 2.2.1. Means (*SD*) of the risk perceptions in the different conditions for persons with higher and lower subjective numeracy (Study 1)

Reference information	Probability level	Subjective numeracy: Lower	Subjective numeracy: Higher
No	Lower	2.16 (1.18) (n = 73)	1.81 (1.05) (n = 80)
	Higher	2.56 (1.07) (n = 70)	2.45 (1.05) (n = 69)
		t (141) = -2.08 p = .04	t (147) = -3.70 p < .001
Yes	Lower	2.36 (1.20) (n = 59)	1.86 (1.10) (n = 65)
	Higher	2.42 (1.26) (n = 52)	2.54 (1.03) (n = 65)
		t (109) = -.29 p = .77	t (128) = -3.61 p < .001

Note: 6-point scale: 1 (very low) – 6 (very high)

The ANCOVA showed a significant main effect for subjective numeracy, $F(1, 525) = 4.06$, $p = .05$, and a significant interaction effect of probability level x subjective numeracy on risk perception, $F(1, 525) = 5.25$, $p = .02$. All other effects, including the main effect for probability level, were not significant in the ANCOVA, $Fs \leq 1.72$, $ps \geq .19$. The interaction numeracy x probability level was thus significant in both analyses.

In sum, the analyses showed that persons with higher subjective numeracy differentiated between the two probability levels, whereas persons with lower subjective numeracy did not, or at least not to the same degree. Adding reference information did not significantly influence the participants' risk perceptions in the multivariate analyses. However, planned comparisons revealed a tendency for reference information to impede the ability of persons with lower numeracy to have different risk perceptions.

Discussion Study 1

The results of Study 1 suggest that persons with higher subjective numeracy perceived more risk when confronted with a higher probability than when confronted with a lower probability. These results are partly in line with our first hypothesis. This contradicts the results of a previous study that suggest that pictographs neither influence risk perception for persons with high numeracy nor for persons with low numeracy (Keller & Siegrist, 2009). This also seems to imply that pictographs can be useful for evoking a meaningful risk perception when some aspects of the pictograph are changed (probability level, size of denominator).

Adding reference information, however, changed this picture in an interesting and rather surprising way. Persons with higher subjective numeracy differentiated between the higher and the lower probability irrespective of the presence of reference information. For persons with lower subjective numeracy, on the other hand, reference information seemed to actually limit the perception of the difference between the higher and the lower probabilities. Our second hypothesis was thus not confirmed for the lower numeracy groups. On the contrary, our results seemed to suggest that pictographs that include reference information are not suitable for communication with persons with lower numeracy.

One possible explanation for this rather surprising impact of reference information may be explained by the fact that pictographs depict numerical information, albeit graphically illustrated, and that people may also tend to treat the pictographs like numerical information. According to Peters' (2008) model of numeracy and the comprehension and use of numeric risk information, persons with high numeracy focus more on numerical information and draw more meaning from numbers than persons with low numeracy. Therefore, persons with higher numeracy may focus on the depicted numbers when they are looking at the pictographs so that the graphical reference information may actually lead to the mere comparison of two numbers for this group. Persons with lower numeracy, on the other hand, may not focus on these numbers. This, in turn, may have impeded the explanatory power of the pictographs with reference information, especially in the lower probability condition where target probability (2 in 100) and reference information (4 in 100) were rather close together. Therefore, it is possible that this different manner of processing the graph has led to different risk perceptions between these two groups. To test the idea that persons with higher numeracy pay more attention to the numerical information in pictographs than persons with lower numeracy, we conducted Study 2.

Study 2

We suggest that pictographs can be processed in different ways. Either one counts the icons and calculates how many persons are affected (focus on the numbers 'behind' the graph), and/or one compares the marked icon area with the unmarked icon area (holistic processing of the graph). According to Peters' (2008) model of numeracy and the comprehension and use of numeric risk information, persons with higher numeracy focus more on, and pay more attention to, numerical information than persons with lower numeracy. This implies that persons with higher numeracy may pay more attention to the actual numbers ‘hidden behind the pictograph’, whereas persons with lower numeracy process the pictograph on a more holistic level. To test this idea, we analysed interviews with laypeople about the processing of a pictograph (10x10 icons) in regard to counting the icons. We expected that higher numeracy would be related to a higher tendency to count the icons and to look for the actual numbers depicted in the graph.

Method Study 2

Study 2 consisted of face-to-face interviews with 52 persons from the general population. These interviews were conducted in the context of a larger study about the processing of various graphical risk communication formats. The participants were recruited from an earlier study in which they had been asked whether they would participate in this study. Fifty-two persons agreed to participate (participation rate = 66%). Participation took about one hour (approximately 12 minutes of this hour were dedicated to the pictograph) and was financially compensated. Of the 52 participants, 16 (31%) were women. Respondents were between 22 and 73 years old (M = 52.25 years, SD = 13.95). Four (8%) had finished lower secondary school, 17 (33%) upper secondary vocational school, 6 (11%) upper secondary school, and 25 (48%) university/technical university.

The study took place in our test laboratory. All participants read a hypothetical scenario on a 15.4-inch computer screen about a man (‘Hans’) who had a screening test for lung cancer. As in Study 1, the test result was communicated with a personalized pictograph (10x10 icons). The depicted probability for Hans having lung cancer was 14%, visualized as 14 marked icons in 100 (see Figure 2.2.2). All participants read the same scenario and looked at the same graph with the task to estimate the depicted probability level. After this, the experimenter conducted an interview about the processing of the graph, particularly dealing with the question about whether the participant had counted the icons or not. The interviews were then transcribed and coded as either 1, meaning the icons were counted, or 0, meaning the icons were not counted (variable ‘counting’). Furthermore, we analysed the transcripts in regard to whether the participants had spontaneously mentioned (i.e., without us asking for this information) the numbers depicted in the graph in the form of percentages or frequencies (coded as 1 ‘yes’ or 0 ‘no’; variable ‘mentioning numbers’).

Figure 2.2.2. Pictograph used in Study 2

To measure numeracy, we applied the same subjective numeracy scale as in Study 1 (Fagerlin et al., 2007) and a short and modified version of the objective numeracy scale used by Lipkus and colleagues (2001). Because there had been ceiling effects when the original tasks were used in a Swiss sample (Keller & Siegrist, 2009), we made the tasks more difficult to achieve a more balanced distribution of scores.[2] The scale we used consisted of seven mathematical tasks, and resulted in a minimum score of 0 and a maximum score of 7. Despite these changes, the distribution was negatively skewed. The mean subjective numeracy was 4.40 (*SD* = .74), and the mean objective numeracy was 5.44 (*SD* = 1.50). The internal consistencies of both scales were acceptable, with Cronbach's α = .81 (8 items) and .63 (7 items), respectively, and the two measures showed a significant positive correlation, $r = .44$, $p = .001$. All statistical analyses were performed with SPSS version 17.0 (SPSS, Inc.).

Results Study 2

Thirty-four participants (65%) reported having counted the icons, and 14 (27%) reported that they had not counted the icons to estimate the probability. Four participants (8%) did not provide any or only unequivocal information about having counted the icons or not. Thirty-

[2]For example, instead of asking, 'If the chance of getting a disease is 20 out of 100, this would be the same as having a __ % chance of getting the disease', we asked, 'If the chance of getting a disease is 250 out of 2000, this would be the same as having a __ % chance of getting the disease'.

one participants (60%) spontaneously mentioned the depicted numbers either as percentages or as frequencies, whereas 21 (40%) did not mention the exact numbers.

The correlations between these two variables and subjective/ objective numeracy are shown in Table 2.2.2. As expected, numeracy was associated with counting the icons and mentioning the numbers depicted in the graph. However, counting the icons was only significantly associated with objective numeracy, and mentioning the numbers was only significantly correlated with subjective numeracy. Subjective numeracy can be further broken down into ability and preference subscales (Fagerlin et al., 2007). Doing this showed that mentioning the numbers was correlated with the ability scale (r = .44, p = .001), but not with the preference subscale (r = .15, p = .30). Neither the ability nor the preference subscale was significantly associated with counting the icons (rs ≤ .16, ps ≥ .27).

Table 2.2.2. Correlations of the coded processing variables with numeracy in Study 2

	Subjective Numeracy	Objective Numeracy
Counting the icons	.14	.34*
Mentioning numbers	.35*	.11

Note: * p < .05

Discussion Study 2

The results of Study 2 supported our hypothesis. We found that persons with higher objective numeracy counted the icons slightly more often than persons with lower objective numeracy, and persons with higher subjective numeracy were more likely to mention the numbers depicted in the graph than persons with lower numeracy. This finding is in line with previous research highlighting that, overall, persons with higher numeracy focus more on numerical information and draw more meaning from these numbers than persons with lower numeracy (Peters, 2008). We assume that persons with lower numeracy may perceive the graph rather holistically (e.g., comparing the areas of the graph or judging the graph by a gut-feeling) because they pay much less attention to the numerical information than persons with higher numeracy.

Further analyses of the subscales of subjective numeracy showed that it was the self-reported ability and not the self-reported preference that was associated with the processing of the graph. Thus, it does not seem to be the liking of numbers that is related to the perception of the graph, but numeracy in the narrower sense, namely people's mathematical skills.

In sum, Study 1 suggested that pictographs are useful for both persons with higher and lower subjective numeracy. However, this effect seems to be more stable for persons with higher numeracy because they differentiated between the higher and the lower probability, irrespective of the presence of a reference information graph. Study 2 implied that persons with higher numeracy seem to concentrate more on the numbers 'behind the pictograph' than person with lower numeracy. Taken together, all of these results suggest that it may be useful to prompt persons with lower numeracy to count the icons of the pictograph or to focus on the number depicted in the graph to make the positive effect of pictographs also more stable for this group. To gain further insight into this relationship between processing pictographs and numeracy, we conducted Study 3.

Study 3

Prompting persons to count the icons of a pictograph may be effectively accomplished by carefully choosing the tasks that participants have to solve. On the one hand, a risk perception task, as we used in Study 1 (e.g., 'how high is this probability?'), probably does not trigger a special type of processing. We therefore expect participants to choose their default way of processing the pictograph. Based on the results of Study 2, we assume that the default way of processing is focusing on numbers and counting the icons for persons with higher numeracy and perceiving the graph rather holistically for persons with lower numeracy. On the other hand, a numerical understanding task, such as those used in previous studies (e.g., 'how many people are affected?'), may trigger all participants to count the icons because the answer to this question is an explicit number (see Galesic et al., 2009; Hawley et al., 2008; Zikmund-Fisher et al., 2008a).

To test whether inducing a focus on the numerical information in the graph influences participants' risk perceptions, we conducted Study 3. We had the following two hypotheses. First, we expected that persons with lower and higher numeracy who are not triggered to count the icons would differentiate between a lower and a higher probability depicted in a pictograph (i.e., replication of the effect in Study 1; Hypothesis 1). Second, we expected that persons with lower numeracy who were triggered to count the icons would differentiate more strongly between a higher and a lower probability than persons with lower numeracy who had not been triggered to count the icons (Hypothesis 2). We did not expect this effect for persons with higher numeracy, because their default way of processing the graph may be counting the icons. Therefore, we assumed that prompting to count the icons would have no further effect on this group of persons.

Method Study 3

Participants and procedure

An online questionnaire was sent to a panel of Swiss households and was answered by 601 persons. We excluded eleven of the respondents because their data were incomplete in regard to risk perception or numeracy. Our analyses were thus based on the answers of 590 participants. Of these, 304 were women (52%). The participants were between 18 and 69 years old (M = 38.69 years, SD = 12.42). Thirty-two respondents (5%) had finished primary or lower secondary school; 248 (42%) upper secondary vocational school; 142 (24%) upper secondary school; and 168 (29%), university/technical university.

We used the same scenario and the same graphs as in the no-reference conditions of Study 1 (upper part of Figure 2.2.1). On the first screen, all respondents read the hypothetical text about 'Daniela' who had been tested for colon cancer and who had the test results communicated to her by means of a 10x10-pictograph with grey and white icons representing Daniela's probability of colon cancer. Three factors were used for a between-subjects design in this study. First, as in Study 1, the level of probability participants saw on the screen was either lower (2 in 100) or higher (17 in 100). Following this procedure, we again examined whether the participants differentiated between the lower and higher probabilities in their risk perception. The second factor we manipulated was the order of the two tasks to test whether a task that triggers the counting of the icons influences how a risk is perceived. The two tasks were: a) a risk perception task with the question, 'How high do you estimate the probability of Daniela having colon cancer?' and b) a numerical understanding task with the question, 'How many people similar to Daniela have cancer?'. The latter question was intended to trigger the counting of the icons. Half of the participants saw the risk perception task first and then, on a second screen, the numerical understanding task (the 'non-counting first' condition). The other half saw the numerical understanding task first and then the risk perception task (the 'counting first' condition). This procedure resulted in four versions of the online questionnaire to which the participants were randomly assigned.

As a third factor, we took participants' subjective numeracy into account, measured with the SNS (Fagerlin et al., 2007; see Study 1 for details about the scale). Using a median split, the respondents were again divided in two groups: a higher numeracy group and a lower numeracy group. Because this study was a self-administered online questionnaire, we did not measure objective numeracy for the same reasons as in Study 1, namely lack of control regarding whether the participants used a calculator, and an increased percentage of drop-outs with objective numeracy.

Data analysis

Again, we used the same analyses as in Study 1. For ease of interpretation, we performed a median split on subjective numeracy and included these two numeracy groups (higher vs. lower), probability level (higher vs. lower) and task sequence (counting first condition vs. non-counting first condition) in an analysis of variance (ANOVA) with the probability measure from the risk perception task as the dependent variable. To test which of the cells were significantly different, we used independent t-tests. However, as subjective numeracy is a continuous variable, we conducted an additional analysis of covariance (ANCOVA) with probability estimate as the dependent variable, the probability level and task sequence as factors and subjective numeracy as a continuous covariate. All statistical procedures were performed with SPSS version 18 (SPSS, IBM corp.).

Results Study 3

Mean subjective numeracy was 4.11 (SD = .90, scale 1– 6); the internal consistency of the SNS was good (8 items; Cronbach's α = .83). We performed a median split on subjective numeracy (Mdn = 4.25), which resulted in a higher-numeracy group (n = 296) and a lower-numeracy group (n = 294).

The ANOVA showed significant main effects for task sequence, $F(1, 582) = 9.08$, p = .003, and for probability level, $F(1, 582) = 40.16$, $p < .001$. Furthermore, we found a significant 3-way interaction effect between numeracy, probability level, and task sequence, $F(1, 582) = 5.53$, $p = .02$. All other effects were non-significant, Fs ≤ 2.19, ps $\geq .14$. Planned t-tests showed that persons with higher subjective numeracy who had seen the higher probability judged this probability to be higher than persons with higher subjective numeracy who had seen the lower probability, irrespective of which task was first (see Table 2.2.3). For persons with lower subjective numeracy, on the other hand, whether they had to solve the numerical understanding task first or the risk perception task affected their perceptions. Only persons with lower subjective numeracy who were in the non-counting first condition (risk perception task first) showed a significant difference between the risk perceptions of the two probability levels. The risk perceptions of persons with lower numeracy in the counting first condition did not differ between the lower and the higher probability level.

Table 2.2.3. Means (*SD*) of risk perception in the different conditions for persons with higher and lower subjective numeracy (Study 3)

Task sequence	Probability level	Subjective numeracy	
		Lower	Higher
Counting first	Lower	1.97 (1.19) (n = 71)	1.60 (0.84) (n = 83)
	Higher	2.16 (0.71) (n = 82)	2.37 (0.97) (n = 67)
		t (110.52) = -1.15 p = .25	t (148) = -5.22 p < .001
Non-Counting first	Lower	1.48 (0.87) (n = 56)	1.63 (1.21) (n =80)
	Higher	2.04 (0.68) (n = 85)	2.05 (0.71) (n = 66)
		t (97.54) = -4.01 p < .001	t (131.32) = -2.62 p = .01

Note: 6-point scale: 1 (very low) – 6 (very high)

The ANCOVA confirmed the 3-way interaction effect between task sequence, risk level and subjective probability, $F(1, 582) = 4.77$, $p = .03$. Furthermore, there was a significant 2-way interaction effect between task sequence and risk level, $F(1, 582) = 4.52$, $p = .03$. All other effects in the ANCOVA were non-significant, Fs ≤·1.86, ps ≥ .17.

Furthermore, 257 of the 296 persons with higher numeracy (87%), and 217 of the 294 participants with lower numeracy (74%) gave the correct answer to the numerical understanding task (‘2’ or ‘17’). Significantly more persons with higher numeracy solved this task correctly than persons with lower numeracy, χ^2 (1, N = 590) = 15.82, p < .001. Hence, this confirmed the assumption that people with higher numeracy are better able to solve numerical problems than those with lower numeracy.

To check whether the results of the ANOVA described above were influenced by whether the participants had correctly answered the numerical understanding task, we recalculated the analyses, this time only including participants who had given the correct answer. This procedure did not change the results: The main effects for task sequence, $F(1, 466) = 15.80$, p < .001, and probability level, $F(1, 466) = 67.50$, $p < .001$, remained significant, as well as the 3-way interaction effect, $F(1, 466) = 8.78$, $p = .003$.

Overall, the analyses showed that task sequence was important for persons with lower numeracy to differentiate between the higher and the lower probability. In the lower numeracy group, solving the risk perception task first seemed to result in different risk perceptions in line with the different probability levels, whereas when persons with lower numeracy had to solve the numerical understanding first, they seemed to perceive the risks of the higher and lower probabilities as similar. Persons with higher subjective numeracy, on the other hand, differentiated between a higher and a lower probability irrespective of task sequence.

Discussion Study 3

We replicated the effect from Study 1 by showing that pictographs are a useful tool to evoke differentiating risk perceptions in persons with higher and lower numeracy. We were thus able to confirm our first hypothesis. However, our expectation concerning the second hypothesis was not met by our data. We expected that triggering persons with lower numeracy to count the icons would lead to a larger difference in risk perceptions. However, in contrast, the results of Study 3 suggest that guiding people with lower numeracy towards counting the icons of a pictograph may impede their ability to draw meaningful information from this type of graph. Persons with lower numeracy may draw the meaning of the information directly from the pictograph without focusing too much on the numbers behind the graph, when they are not prompted to count the icons first. However, when they are stimulated to count the icons first, they may have the exact number in mind. In this case, they may not be able to draw meaning from this number because of their lower numeracy skills (see Peters, 2008), so that their risk perceptions are not affected by the probability levels. This mechanism would explain why pictographs are useful for people with lower numeracy to *understand* medical information numerically (e.g., knowledge about how many people are affected by a certain disease; Galesic et al., 2009; Hawley et al., 2008; Zikmund-Fisher et al., 2008a) but that the mechanism becomes more complex when it comes to evoking differentiating risk *perceptions* (Keller & Siegrist, 2009). For persons with higher numeracy, focusing on the numbers depicted in a graph seems to be intuitive and advantageous, whereas this procedure may be rather counter-intuitive and impeding for persons with lower numeracy.

General discussion

Researchers have recommended using graphical displays, such as pictographs, to improve communicating risk to persons with low numeracy (Apter et al., 2008; Nelson et al., 2008). Our results suggest that pictographs might be useful for persons with higher and lower numeracy—but for different reasons and under different conditions. To use pictographs for effective communication, it is helpful to understand these reasons and conditions. Our results imply that persons with higher numeracy may profit from this type of graph because they more often draw the exact numbers from it and turn these numbers into a subjective risk perception that enables them to differentiate between higher and lower levels risk. Thus, one could also provide this group with the numbers alone and the effect would probably be comparable. Persons with lower numeracy, on the other hand, seem to process this kind of graph differently. They seem to rely on a different type of information, and not on the numbers 'hidden in the graph'. This is in line with Peters' (2008) model of numeracy and the comprehension and use of numeric risk information. Even more, our results imply that guiding individuals with lower numeracy towards attending to the numbers in the graph may even be counterproductive and confusing for this group. All in all, our results suggest that pictographs for persons with lower numeracy should be as simple as possible to facilitate a processing of the graph that is relatively unaffected by numerical information or calculations. Some additional verbal information about the meaning of the information depicted in the pictograph, e.g., in the form of verbal labels, could also be useful for persons with lower numeracy to ease the understanding of this information (see Peters, Dieckmann, Mertz, Vastfjall, Slovic & Hibbard, 2009). However, this should be done carefully because labelling numbers might influence a person's behavioural intentions (Zikmund-Fisher et al., 2007a).

Overall, our studies provided rather clear indications of which information persons with lower numeracy do *not* rely on when they look at pictographs: namely, the numbers. However, we could only assume which information they *do* rely on to build up their risk perceptions. Based on the assumption that there are two basic ways of processing pictographs (focus on numbers and holistic processing), in Study 2, we suggested that persons with lower numeracy might perceive the graph rather holistically. However, further studies are needed that explore the crucial parts of information that are used by persons with lower numeracy to build their risk perceptions.

Both Studies 1 and 3 showed differences between persons with higher and lower numeracy in the lower probability condition, whereas the two groups gave rather similar answers in the higher probability conditions. Our procedure does not provide information about correct or incorrect answers because risk perception is subjective and, therefore, cannot be right or wrong. Thus, we cannot conclude from our results that persons with lower numeracy understand small probabilities less than persons with higher numeracy. However, we can conclude that lower probabilities rather than higher probabilities seem to be processed and judged differently by persons with higher and lower numeracy. Further studies are needed to shed more light on this crucial aspect of communicating risk to persons with lower numeracy.

Finally, some methodological issues and limitations of our studies should be considered. First, we had three rather different samples with regard to socio-demographic variables. Furthermore, the level of risk perception was higher in the first than in the third study although we used the exact same scenario. As the samples were quite similar in regard to numeracy levels, the discrepancy between the risk perceptions in Studies 1 and 3 can, therefore, probably be explained by the lower mean age of the sample in Study 3. The lower age in Study 3 can, in turn, be the result of the type of data gathering (online vs. paper-pencil questionnaire). Second, we used only one special type of pictograph in all studies. However, the pictographs' characteristics, for example, the denominator or the order of the marked icons, can influence the perception and understanding of the depicted information (Feldman-Stewart et al., 2000; Galesic et al., 2009; Zikmund-Fisher et al., 2008b). We, therefore, do not know whether our results can be generalized to all types of pictographs. Third, Study 2 was a qualitative and explorative study using unstructured interviews and a small sample with more men than women. Therefore, these results should be interpreted with caution and be confirmed in a larger and more representative sample. However, we think Study 2 provides an important and, above all, new input for the interpretation of pictographs by directly examining the processing of the graph rather than solely the understanding of the depicted information. Finally, we measured numeracy in Studies 1 and 3 with only the subjective numeracy scale, and not with an objective measure. As Study 2 showed, the two measures are significantly correlated, but not very highly. It is unclear whether we would have found the same results with an objective numeracy scale.

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III
Promoting a healthy lifestyle - nutrition communication

Chapter 3.1
The role of health-related, motivational and socio-demographic aspects in predicting food label use: a comprehensive study

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Abstract

Objective: Previous studies focused on a limited number of determinants of food label use. We therefore tested a comprehensive model of food label use consisting of sociodemographic, health-related and motivating variables. These three predictor groups were chosen based on the previous literature and completed with new predictors not yet examined in a comprehensive study of frequency of label use.

Design: We sent questionnaires to a random sample of households in the German-speaking part of Switzerland.

Setting: The respondents filled in the questionnaire at home and returned it by mail.

Subjects: We analysed the data of 1162 filled-in questionnaires (response rate = 38%). Of the respondents, 637 were women (55%), and their mean age was 53.54 (*SD* 15.68) years.

Results: Health-related variables were the most important group of predictors of label use, followed by motivating factors and sociodemographic variables. Placing importance on health, healthy eating and nutritional value of food, perceived vulnerability for diet-related diseases, nutrition knowledge, numeracy and gender were positively associated with frequency of food label use, whereas shopping habits and seeing eating as something positive were negative predictors of frequency of label use.

Conclusions: People's health consciousness should be raised in order to increase the frequency of food label use. Furthermore, it should be stressed that reading labels and keeping a healthy diet do not contradict 'good eating', and that both of these aspects can be combined with the help of food labels.

Introduction

Nutrition labels on food products are often praised as an important instrument for health promotion and prevention of diseases associated with overweight and obesity (Baltas, 2001; Cowburn & Stockley, 2005; Grunert & Wills, 2007; Ni Mhurchu & Gorton, 2007). To find out how this preventive strategy can be used optimally and where the potential starting points for further improvement could be, it is very important to understand what determines use of food labels. This knowledge would help public health communicators to decide to whom and how they need to promote food label use. However, to our knowledge, existing studies investigating food label use have focused mainly on either sociodemographic and economic variables or on health-related factors. No study has systematically included factors inhibiting label use. The aims of the present study were, therefore, to provide a comprehensive framework of determinants of nutrition label use and to shed light on the motivators and inhibitors of nutrition label use. Thereby, we paid attention to three groups of potential determinants of label use: (i) a person's sociodemographic and economic background; (ii) health-related aspects; and (iii) factors which discourage people from using food labels (see Figure 3.1.1). We now discuss the relevant factors of each of these three determinants, based on previous studies. One difficulty of studying label use is the number of different labels in the different international markets and the difference in measuring label use (e.g. frequency of label use v. are labels used at all – yes or no). As we are interested in factors predicting the frequency of label use, we focus mainly on studies investigating frequency of label use (i.e. how often people use labels) and less on studies investigating whether labels are used at all.

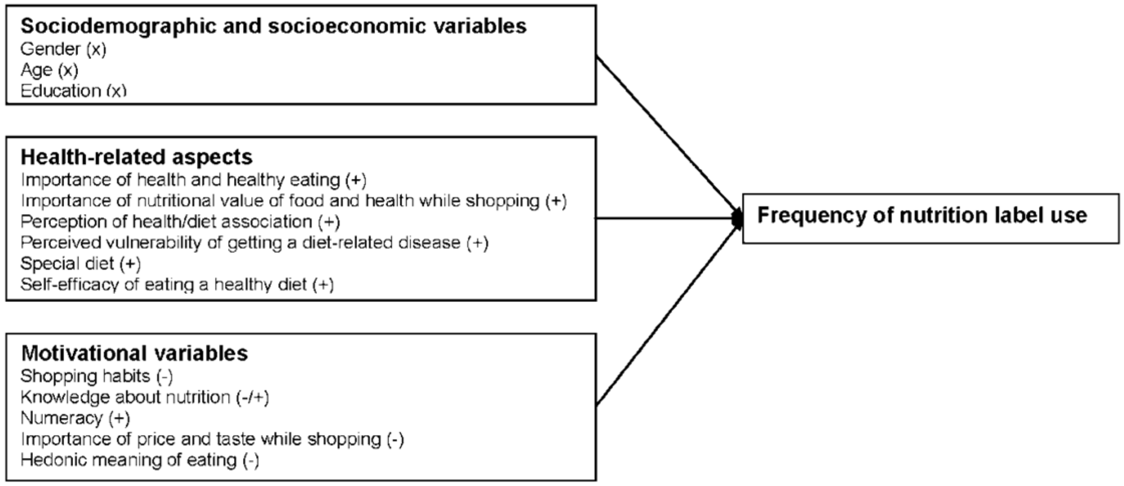

Figure 3.1.1. A comprehensive model of determinants of label use. Expected direction of associations, based on previous literature: -, negative relationship expected; +, positive relationship expected; -/+, relationship expected, unclear in which direction; x, no relationship expected

First, regarding sociodemographic and economic variables, review studies suggest that women, better educated people and younger people usually report looking at nutrition labels more often (Baltas, 2001; Cowburn & Stockley, 2005; Drichoutis et al., 2006). Furthermore, additional situational factors, for example, type of household and perceived importance of price, seem to play a role in determining whether people look at nutrition labels or not (Drichoutis et al., 2006; Grunert & Wills, 2007). However, in studies in which several types of sociodemographic and situational variables were looked at together, the picture is not that clear any more (Drichoutis et al., 2005; Drichoutis et al., 2008; Kim et al., 2001; Nayga, 2000; Nayga et al., 1998). There were no clear and consistent associations between the sociodemographic variables and frequency of label use. For example, two studies found that men used labels less often than women (Drichoutis et al., 2008; Kim et al., 2001); however, others did not find any effect of gender on degree of label use. In one study, age had a negative effect on frequency of label use (Drichoutis et al., 2008), whereas no other studies found significant effects for age. Furthermore, no studies found associations between education or income and degree of label use except one study which found that higher education was associated with more label use and higher income with less label use (Drichoutis et al., 2005). One reason for these inconsistent findings could lie in the different sets of predictor variables used in these studies. For example, the studies that found no effect for gender included importance of price, nutrition and taste (Drichoutis et al., 2005; Nayga, 2000; Nayga et al., 1998), whereas the ones that found a gender effect did not include these variables in the set of predictors (Drichoutis et al., 2008; Kim et al., 2001). Therefore, it seems as if the effects of sociodemographic variables sometimes disappear when underlying variables are included in the model. Our aim is to clarify the role of sociodemographic variables in label use by including all main predictor variables that have been investigated separately in one model. Following this procedure, we intend to investigate which of the sociodemographic variables might be genuine predictors of label use and which are rather proxies for underlying factors.

Second, these studies measured several health-related variables that may influence label use. These variables, for example, being on a special diet (Drichoutis et al., 2005; Kim et al., 2001; Nayga et al., 1998), believing that there is a relationship between diet and disease (Kim et al., 2001; Nayga, 2000), placing importance on nutrition (Nayga, 2000; Nayga et al., 1998) as well as placing importance on following dietary guidelines (Nayga, 2000; Nayga et al., 1998), seem to be related to more frequent label use. Other studies also supported the importance of health-related aspects for label use (see Baltas, 2001; Cowburn & Stockley, 2005; Drichoutis et al., 2006 for reviews of this literature). For example, having a strong belief in a relationship between diet and cancer, interest in healthy eating and being confident that one is able to eat healthily were associated with whether participants used labels at all (Grunert et al., 2010a; Grunert et al., 2010b; Neuhouser, Kristal & Patterson, 1999; Satia et al., 2005). Furthermore, Petrovici and Ritson (2006) found that self-reported nutrition knowledge and health motivation were positively related to frequency of label use. Perceived threat of nutrition-related diseases was negatively related and perceived effectiveness of diet to decrease the risk of disease was positively related to self-reported healthiness of diet. However, these two latter variables were not associated with label use.

In sum, health-related aspects, such as the importance of health and a healthy diet, seem to play an important role in why some people use labels. However, everybody is not interested in health and healthy eating, and mere exposure to food labels does not necessarily lead to food label use and decisions to use healthy food products (Grunert et al., 2010a; Grunert et al., 2010b). Thus, one should additionally consider a third group of determinants; namely, the motivational reasons people do not use labels. Gorton and colleagues (2009) asked their participants about their reasons for not using nutrition labels. In addition to not being interested in healthy eating, the participants mentioned not needing more information about food, not understanding labels and having priorities other than healthy eating (Gorton et al., 2009).

Reading labels might, therefore, sometimes simply not be necessary for picking healthy food products because people always buy the same products and, therefore, know the products very well. Similarly, one reason people gave for not looking at health endorsements on products in a study by Rayner, Boaz and Higginson (2001) was that buying food products was a habit, making reading labels superfluous. Shopping habits might therefore be associated with less label use. Food and nutrition knowledge might play a similar role in determining food label use. People who know a lot about healthy eating might not consider looking at labels necessary because they already know enough about the nutritional value of the food product they are buying. Some studies point in this direction as they showed no effect of nutrition knowledge on the probability of label use (Drichoutis et al., 2008; Nayga, 2000; Nayga et al., 1998). However, this might not be the only way in which nutrition knowledge can interact with label use because other studies suggest that nutrition knowledge is positively associated with label use (Drichoutis et al., 2005; Fitzgerald, Damio, Segura-Perez & Perez-Escamilla, 2008; Grunert et al., 2010a; Grunert et al., 2010b; Petrovici & Ritson, 2006). Thus, having high nutrition knowledge might reflect a basic interest in healthy eating and could, therefore, be associated with even more label use.

Another reason why the participants in Gorton and colleagues' (2009) study did not use labels was that the participants did not understand the labels. According to Grunert and colleagues' (2010a; 2010b) conceptual framework of food label use, the relationship between the perception of labels and the actual and meaningful use of the information in the labels is influenced by factors associated with understanding the label. Similarly, perceived ease of label use and observed efficiency of label use have been shown to be associated with more label use (Drichoutis et al., 2008; Kim et al., 2001). Therefore, factors that are negatively associated with actual understanding of labels and/or confidence in understanding labels might also be negatively related to label use. Numeracy is such a potentially inhibiting factor, as it is associated with less understanding of nutrition labels (Rothman, Housam, Weiss, Davis, Gregory, Gebretsadik, Shintani & Elasy, 2006). In the same study, there was also a weak indication that label use was different for persons with high numeracy and for persons with low numeracy (Rothman et al., 2006).

Finally, participants in Gorton and colleagues' (2009) study mentioned having priorities other than healthy eating as a reason why they do not use labels. Importance of price was negatively associated with frequency of nutrition label use in Drichoutis and colleagues' (2005) study. Furthermore, the perception of eating as a primarily hedonic experience might also inhibit people from looking at labels. The results of an eye tracking study suggested that being motivated to look for tasty food was associated with less attention to nutrition tables than being motivated to choose healthy products (Visschers, Hess & Siegrist, 2010). Furthermore, Drichoutis and colleagues (2005) found importance of taste to be negatively related to whether people used labels at all or not (irrespective of how often they use it). Thus, having priorities, such as having a tight budget for buying food products or placing importance on the hedonic aspects of eating, might keep people from using labels, whereas health motivation may enhance label use.

We included all of these aspects described above in one comprehensive model of determinants of label use (see Figure 3.1.1). We thereby aimed to answer the question which determinants influence whether people do or do not use labels and, based on these important determinants, to suggest implications for public health practice. Based on the literature described above, we expect that the health-related variables are the most important positive predictors of label use, followed by the motivational variables, which we expect discourage people from using labels (see Figure 3.1.1). Because the studies described above showed very inconsistent results regarding sociodemographic and economic variables, we hypothesise that these variables are rather proxies of underlying health-related motivators and inhibitors of label use and will therefore not be associated with label use when controlling for the other two groups of variables.

Method

Procedure and sample

We sent a questionnaire to a sample of households in the German-speaking part of Switzerland. This sample was randomly chosen from the Swiss telephone book, the best available directory for the Swiss general population. The first questionnaire was sent to the households in September 2009. Seven weeks later, we sent a reminder letter to the households from which we had not yet received a filled-in questionnaire. Following this procedure, we received 1162 filled-in questionnaires (response rate 38%) from 637 women (55%) and 508 men (44%). Seventeen persons (1%) did not specify their gender. In our sample, 109 persons (9%) had finished primary or lower secondary school, 530 (46%) upper secondary vocational school, 194 (17%) upper secondary school and 309 (26%) university/technical university; twenty (2%) persons did not state their educational background. The respondents' mean age was 53.54 (*SD* 15.68) years. According to Swiss Federal Statistical Office data (Bundesamt für Statistik, n.d.), men, people with primary or lower secondary school education and younger people were slightly under-represented in our sample. Nevertheless, our sample was a good representation of the German-speaking part of Switzerland.

Questionnaire

The questionnaire contained questions about all of the variables and constructs listed in Figure 3.1.1. Most of the predictor concepts and the outcome variable label use were assessed in scales consisting of several items (see Table 3.1.1). We based the items of these scales on several previous studies that had examined knowledge, attitudes and beliefs in a health and nutrition context, or numeracy (Dickson-Spillmann, Siegrist & Keller, 2011; Dutta-Bergman, 2004; Fagerlin et al., 2007; Jayanti & Burns, 1998; Kristal, Bowen, Curry, Shattuck & Henry, 1990; Lee et al., 2008; Petrovici & Ritson, 2006; Schifferstein & Oude Ophuis, 1998), and completed them with our own questions. Table 3.1.1 presents the scales used in the study with one item example each, the internal reliability, mean sum score, number of respondents and original sources.[3] We calculated the means of the scales for all persons who had filled in more than half of the items of a scale.

We measured our outcome variable label use by asking the respondents how important labels are when they are choosing food products, and how often they used labels in three different situations (choice of food products one has never bought before, decision between two or more food products, judging how healthy a product is). We chose these situations based on the study by Higginson, Kirk, Rayner and Draper (2002a), which showed that these situations are important application fields of food labels. In Switzerland, labels in the form of nutrition tables are the standard form of food labelling, although recently front-of-package labels have been appearing more and more in stores. We focused our questions on the standard nutrition table to be sure that all respondents have been exposed to the labels we are studying. As can be seen in Table 3.1.1, knowledge was measured in two ways. On the one hand, it was assessed as self-reported knowledge (‘subjective knowledge’) and on the other hand as a score on a short knowledge scale (‘objective knowledge’). We chose to measure these two aspects of knowledge as both have been shown to be important for label use (Drichoutis et al., 2005; Fitzgerald et al., 2008; Petrovici & Ritson, 2006).

[3] Due to space restrictions, not all items on the questionnaire can be listed here. However, the items can be obtained from the first author upon request.

Table 3.1.1. Description of predictors and outcome variables measured on 6-point Likert-scales (1 = do not agree, 6 = agree, if not mentioned otherwise) and example items

	Number of items	*M*	*SD*	*N*	α
Outcome variable					
Food label use	4	3.33	1.59	1149	.934
How often do you use labels when you buy a product for the first time?[1]					
Health-related predictors					
Importance of health	8	4.37	0.88	1138	.783
Living in the best possible health is very important to me.[a]					
Importance of healthy eating	4	3.90	0.99	1139	.712
I am prepared to leave a lot to eat as healthy as possible.[b]					
Importance of nutritional value of food while shopping	1	4.53	1.27	1142	-
How important is the nutritional value of food for you when you are buying food?[2]					
Importance of health while shopping	1	5.10	0.95	1146	-
How important is health for you when you are buying food?[2]					
Perception of health/diet association	4	4.68	0.90	1139	.748
Diet is something very important for my health.[c]					
Perceived vulnerability for diet-related disease	3	2.06	1.01	1136	.844
I am worried about becoming ill in the future because of my diet.					
Self-efficacy of eating a healthy diet	2	4.85	0.96	1141	.643
I can eat a healthy diet when I want to.					
Motivational predictors					
Shopping habits	4	4.19	0.95	1148	.583
I always buy approximately the same food products.					
Self-reported nutrition knowledge	4	4.67	1.01	1149	.720
I know better how a healthy diet looks like compared to the average person.[d]					
Nutrition knowledge	10	6.41	2.06	1150	.548
Bacon contains more calories than ham.[e, 3]					
Numeracy	8	4.14	0.89	1138	.829
How good are you at working with percentages?[f, 4]					
Importance of price while shopping	1	4.34	1.34	1145	-
How important is price for you when you are buying food?[2]					
Importance of taste while shopping	1	5.44	0.79	1144	-
How important is taste for you when you are buying food?[2]					
Hedonic meaning of eating	5	5.35	0.70	1145	.786
Eating well means quality of life for me.					

Note:
1 1 never – 6 very often
2 1 not important at all – 6 very important
3 1 correct answer, 0 incorrect answer/don't know (maximum score = 10)
4 1 not at all good – 6 very good
a From the health consciousness attitude scale by Dutta-Bergman (2004)
b From the health consciousness scale by Schifferstein & Oude Ophuis (1998)
c Based on an item from the attitudes about diet and health scale by Kristal et al. (1990)
d Based on the health knowledge scale by Jayanti & Burns (1998)
e From the consumer-oriented nutrition knowledge questionnaire by Dickson-Spillmann et al. (2011)
f From the subjective numeracy scale by Fagerlin et al. (2007)

In addition to the scales shown in Table 3.1.1, age, gender (0 male/1 female) and education (four categories, see sample description) were assessed as sociodemographic characteristics. Education was turned into three dummy variables with the reference category as ‘upper secondary vocational school’ (i.e. the largest group) so that we could enter this variable into the linear regression model. Furthermore, being on a special diet was measured with one single dichotomous item (‘do you have to adhere to a special diet due to a disease or are you on a diet?’; 0 no/1 yes).

Data analysis

We analysed the data by running a hierarchical regression analysis with the SPSS statistical software package version 17.0 (SPSS Inc., Chicago, IL, USA). The model in Figure 3.1.1. was used as the theoretical framework for the analysis, and we entered the variables blockwise into the regression model. As the previously most examined group of predictors, sociodemographic variables were entered first (step 1), followed by the second already studied group of health-related variables (step 2). Finally, the new set of motivational variables was entered into the model as the last step (step 3).

Results

Mean degree of label use was 3.33 (SD = 1.59) on a scale from 1 (‘never’) to 6 (‘very often’). More respondents reported they never used labels (13%) than reported they always used labels (5%); the rest of the answers were distributed approximately equally between these two extreme points of the scale (25th percentile = 2.0, 50th percentile = 3.5, 75th percentile = 4.75). These results suggest a medium frequency of label use in our sample.

The results of the regression analysis are shown in Table 3.1.2. All of the variable groups (steps) significantly improved the regression model. Overall, sociodemographic, health-related and motivational variables explained 32% of the variance in label use in our sample. The largest part of the explained variance was due to the health-related variables (R^2= 0.190), whereas motivational (R^2= 0.070) and sociodemographic variables (R^2=0.055) were less important for predicting label use.

Table 3.1.2. Regression analysis for label use predicted by sociodemographic, health-related and motivational variables (n = 1013)

Predictor variable	*B*	*SE B*	ß	R^2	*F*	*df*
Step 1 – sociodemographic variables				.055	11.647***	5, 1007
Gender	.357	.098	.112***			
Age	.000	.003	.000			
Education (primary/lower secondary school)	-.107	.155	-.020			
Education (upper secondary vocational school)[a]	-	-	-			
Education (upper secondary school)	.079	.123	.019			
Education (university)	-.016	.110	-.004			
Step 2 – health-related variables				.190	24.914***	13, 999
Importance of health	.249	.081	.139**			
Importance of healthy eating	.274	.070	.172***			
Importance of nutritional value while shopping	.167	.046	.134***			
Importance of health while shopping	-.087	.067	-.053			
Perception of health/diet association	.013	.062	.008			
Perceived vulnerability for diet-related disease	.133	.045	.084**			
Special diet	.070	.155	.012			
Self-efficacy of eating a healthy diet	-.037	.054	-.022			
Step 3 – motivational variables				.070	22.763***	20, 992
Shopping habits	-.147	.045	-.089**			
Self-reported nutrition knowledge	.185	.055	.119**			
Nutrition knowledge	.130	.023	.168***			
Numeracy	.203	.054	.114***			
Importance of price while shopping	.071	.033	.060*			
Importance of taste while shopping	.022	.060	.011			
Hedonic meaning of eating	-.174	.067	-.076**			

Note. F_{Change} (8, 999) = 31.446, $p < .001$ for step 1/2; F_{Change} (7, 992) = 14.418, $p < .001$ for step2/3; $R^2 = .315$ for the final model
* $p < .05$, ** $p <.01$, *** $p < .001$
[a]reference category

In the group of the health-related variables, importance of healthy eating, importance of nutritional values while choosing foods in the supermarket and importance of health in general significantly predicted label use. Thinking that health in general, healthy eating and nutritional values of food are important was associated with more label use. Interestingly however, importance of health while shopping or self-efficacy of eating a healthy diet was not significantly related to label use. There was also one significant albeit weaker association of label use with a disease-related concept: feeling at risk for diet-related diseases was associated with more label use. Being aware of a diet–disease association, on the other hand, was not associated with label use. Therefore, wanting to live healthily seemed to be a more important motivator for label use in our sample than wanting to prevent disease.

The strongest predictor of label use in the group of motivational variables was nutrition knowledge. Being more knowledgeable ('objective knowledge') and also feeling knowledgeable about nutrition and healthy eating ('subjective knowledge') were associated with more label use. Furthermore, the factors that might keep people from using food labels were also important in our model. The strongest inhibiting predictor was numeracy, which was positively related to label use. This suggests that people who do not like numbers and report that they are not good at using numbers use food labels less. Furthermore, having stronger shopping habits and, finally, the hedonic meaning of eating were negatively associated with label use. Therefore, respondents who often buy the same food products and who see eating as something positive use labels less. One predictor of this group turned out to be a motivating and not an inhibiting factor: we expected importance of price to be a negative predictor as it mirrors priorities other than health. However, in this model, placing importance on price while shopping was associated with more label use.

Of the sociodemographic variables, only gender was a significant predictor of food label use, even after controlling for all other possible predictors. Age and education, on the other hand, were not significantly associated with food label use in our model. In sum, health-related aspects, knowledge and inhibiting factors were the most powerful predictors of label use in our model, whereas sociodemographic variables were of little importance.

Discussion

To the best of our knowledge, the present study is the first to apply a more comprehensive model of food label use. In addition to the quite well-established sociodemographic and health-related variables, we included inhibiting factors of label use in our model. Furthermore, our comprehensive model showed that not all variables which appeared important for label use in previous studies were significantly associated with label use when entered into the model together with other predictors.

Two main influence factors on label use emerge from our findings: attitudes toward health and inhibiting factors. First, the most important predictor of label use was importance placed on health and eating. Respondents who considered health, healthy eating and the nutritional value of food as important reported more frequent label use than respondents who did not place importance on these aspects. This finding confirms the crucial role that health-related factors played in earlier studies (Grunert et al., 2010a; Grunert et al., 2010b; Nayga, 2000; Nayga et al., 1998; Neuhouser et al., 1999; Petrovici & Ritson, 2006; Satia et al., 2005). Disease-related aspects, on the other hand, were less important for predicting label use. In sum, these findings imply that people rather use labels because they are interested in health and healthy eating and not primarily because they are afraid of falling ill. Interestingly, people who saw eating as something positive and hedonic reported less label use. Thus, people might perceive food labels as something that spoils the enjoyment of eating or that they do not perceive healthy eating as something positive.

Second, people's skills and usual behaviour seem to be important for how often they use labels. Lower numeracy seems to inhibit food label use. It is thus possible that the merely numerical presentation of nutritional information on the package as is mostly the case in Switzerland might be problematic from a public health perspective. On the one hand, this format may decrease understanding of the label (European Heart Network, 2003) and on the other might cause people to not even look at the label if they think they will not understand the numbers on it anyway. Furthermore, shopping habits were associated with less frequent label use in our study. If somebody's diet is already healthy, this association does not have to be a bad sign for the promotion of healthy eating as label use is not necessary in this case. However, if somebody's diet is not healthy, habits do become a problem for public health as they impede a diet change toward a healthier diet. Interestingly, neither importance of price nor importance of taste played an inhibiting role for label use in our model. Thus, behavioural and skill-related obstacles to label use were more important in our sample than having potentially concurring priorities when shopping. Knowledge seemed rather to be part of a more general interest in healthy eating and less an inhibiting factor for label use as knowledge was associated with more label use.

As expected, the sociodemographic variables we measured did not play a major role in predicting the frequency of label use. Age and education may be correlated with the more crucial underlying factors, such as attitudes or behaviours, and become important only when these factors are not measured. This might explain the mixed results regarding these variables in previous studies (Drichoutis et al., 2005; Drichoutis et al., 2008; Kim et al., 2001; Nayga, 2000; Nayga et al., 1998). Gender, on the other hand, was still a significant predictor in our model. This might imply that women use labels more often than men, even when controlling for health consciousness. However, although we included many potential predictors in our model, it did not explain a large part of the variance of label use. We might not have measured an important underlying factor that is correlated with gender. Further studies are thus needed to find out which factors additionally influence food label use.

Apart from the rather large amount of unexplained variance, several further limitations of our study should be considered. Compared with more direct measures of label use, for example, verbal protocol analysis, in-shop observations or eye tracking, measures of label use that rely on self-reported data, such as questionnaires, might have the disadvantage of resulting in over-reported label use (Goldberg, Probart & Zak, 1999; Grunert et al., 2010a; Grunert et al., 2010b; Jones & Richardson, 2007; Ni Mhurchu & Gorton, 2007; Rayner et al., 2001). Direct measures may thus be the instrument of choice when one wants to know whether people understand the labels and apply them correctly. However, when people do not look at labels, one cannot induce from such measures whether this was the case because of implicit knowledge about the product or shopping habits making looking at the label superfluous, or because of a lack of interest in labels. Therefore, we decided to take the potential disadvantage of overreporting and investigate our research question with a questionnaire. Furthermore, even if there was no overreporting in our study, we cannot know whether people who use labels more often use these labels as a decision aid to buy the healthiest product. In other words, we do not know whether label use translates into a healthier diet (see the last part of Grunert et al.'s [2010a; 2010b] conceptual framework of food label use). As our results suggest that people who are generally interested in health and healthy eating use labels more often than others, we can speculate that they may use labels for choosing healthy foods. However, even if persons interested in health and healthy eating do use labels for this purpose, this does not imply that persuading persons who are not interested in health and nutrition to use labels will have the same effect on this group's behaviour. Finally, another limitation may be that we used short and partly new scales that had not been tested before, and some did not have excellent scale properties. Therefore, these results should be replicated and confirmed in further studies.

Conclusions

Our findings can help public health communicators to focus on crucial determinants of label use in order to promote label use. On the one hand, as an interest in health and healthy eating seems to be the central element in determining the frequency of label use, people's health consciousness should be raised in order to also increase the frequency of food label use. Additionally, if communicators want to directly promote label use and not indirectly via health consciousness, labels should be promoted primarily as an instrument to maintain health rather than as a measure to prevent illnesses. Furthermore, it should be stressed that reading labels and maintaining a healthy diet do not contradict enjoying eating, and that both of these aspects can be combined with the help of food labels. On the other hand, communicators should keep in mind the obstacles of food habits and of perceived low skills that might lead to a decreased frequency of label use. Food labels should be designed in a way which is understandable for everyone. Perhaps some graphical and/or verbal explanations for the numbers should be used on the label or in dietary counselling (European Heart Network, 2003). Public health communicators should take shopping habits into account when promoting label use. People with strong shopping habits and an unhealthy diet should be encouraged to use labels to compare and choose food.

Acknowledgements

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Chapter 3.2
Health motivation and product design determine consumers' visual attention to nutrition information on food products

Vivianne H.M. Visschers, Rebecca Hess and Michael Siegrist

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Abstract

Objective: In the present study we investigated consumers' visual attention to nutrition information on food products using an indirect instrument, an eye tracker. In addition, we looked at whether people with a health motivation focus on nutrition information on food products more than people with a taste motivation.

Design: Respondents were instructed to choose one of five cereals for either the kindergarten (health motivation) or the student cafeteria (taste motivation). The eye tracker measured their visual attention during this task. Then respondents completed a short questionnaire.

Setting: Laboratory of the ETH Zurich, Switzerland.

Subjects: Videos and questionnaires from thirty-two students (seventeen males; mean age 24.91 years) were analysed.

Results: Respondents with a health motivation viewed the nutrition information on the food products for longer and more often than respondents with a taste motivation. Health motivation also seemed to stimulate deeper processing of the nutrition information. The student cafeteria group focused primarily on the other information and did this for longer and more often than the health motivation group. Additionally, the package design affected participants' nutrition information search.

Conclusions: Two factors appear to influence whether people pay attention to nutrition information on food products: their motivation and the product's design. If the package design does not sufficiently facilitate the localization of nutrition information, health motivation can stimulate consumers to look for nutrition information so that they may make a more deliberate food choice.

Introduction

Nutrition information on food products, such as labels and claims, comprise one of the means that help consumers to interpret products' nutritional value. Various scholars therefore have studied how consumers interpret nutrition labels and claims (Cowburn & Stockley, 2005; Geiger, Wyse, Parent & Hansen, 1991; Grunert & Wills, 2007; Jones & Richardson, 2007; Visschers & Siegrist, 2009; Williams, 2005). However, few observational studies have examined whether and how consumers perceive nutrition labels and claims (e.g., Higginson et al., 2002b; Rayner et al., 2001). Food products also include other nutrition information on their packaging, such as the ingredients list and a front-of-package label (FOP), which none of the other studies considered. We therefore aimed to study consumers' visual attention towards all nutrition information on food products, using an indirect measure.

When asked directly, many consumers report observing nutrition labels and claims; sometimes as many as 71% say they do so (e.g., Guthrie, Fox, Cleveland & Welsh, 1995; Nayga et al., 1998). Several demographical variables, such as being female and having a higher education level, as well as concepts related to motivation, such as nutrition importance and health consciousness, appear mainly to determine this behaviour (e.g., Guthrie et al., 1995; Nayga et al., 1998; Neuhouser et al., 1999; Satia et al., 2005; Williams, 2005). The self-report method, however, has insufficient construct validity. Consumers may answer in a socially desirable way or may have difficulty in estimating the frequency of nutrition information use during shopping, as this is determined mainly by habits and external cues which are difficult to verbalize (Dijksterhuis, Smith, van Baaren & Wigboldus, 2005).

Two studies in more realistic shopping situations indicated that consumers showed little interest for nutrition labels and health symbols on products (Higginson et al., 2002b; Rayner et al., 2001). Participants' attention to nutrition labels (Higginson et al., 2002b), but not to health symbols (Rayner et al., 2001), increased impressively when they were instructed to look for healthy food items. However, these studies also have some methodological limitations: (i) the research method used, a think-aloud protocol, made participants aware of their actual behaviour; (ii) only small samples were tested; and (iii) there was little control over the experimental situation. Nevertheless, these studies revealed considerable dissimilarities between consumers' self-reported and observed nutrition information use.

Moorman (1996) observed consumers in the supermarket before and after the implementation of a new nutrition labelling system. One of her findings was that motivated consumers looked more often at food products after the new labelling than before, and more than less-motivated consumers. It was however impossible to determine what kind of information the respondents perceived on the food products. The new labels could also have made other information (e.g. price or ingredients) more difficult to find, so that respondents needed more time to perceive the products.

In sum, previous studies examining whether consumers perceive nutrition information and what type of information they look at have serious methodological shortcomings. Studies using indirect measurements are needed to overcome them. The eye tracker is a promising instrument in this respect because it makes it possible to observe consumers in a more realistic, but controlled, setting, without revealing the purpose of the study.

To the best of our knowledge, only two other studies have utilized an eye tracker to examine consumers' visual attention to nutrition labels (Goldberg et al., 1999; Jones & Richardson, 2007). The aim of both studies was to compare various labels, and the respondents were directly presented with the nutrition labels. This is not very realistic, because nutrition labels are usually presented in the midst of other verbal and graphic information on a package, which can distract consumers from the labels.

In an eye tracker study related to brand management, motivation appeared to increase the duration of respondents' visual attention on the products and to decrease the number of switches between the products, which implied deeper information processing (Pieters & Warlop, 1999). That study thus also indicated that motivation may increase nutrition information use.

In the present study, we aimed to examine the following two issues by means of an eye tracker: (i) how much attention do consumers pay to nutrition information on food products compared with other information while making a food choice? and (ii) does a health motivation lead to more nutrition information use?

Method

Participants

Forty-two students of the University of Zurich and the ETH Zurich participated in the present study, for which they received CHF 20 ($US 19). We excluded ten participants from the analyses as their eye tracker videos contained more than 30% missing data (see Data analysis). Of the remaining thirty-two respondents, seventeen were males (53%) and their mean age was 24.91 (*SD* =5.14) years.

Design, procedure and materials

The experiment included two conditions (health v. taste motivation) using a between-subjects design with random distribution of respondents over the two conditions. Upon arrival in our laboratory, participants were seated at a desk. The experimenter first explained the purpose of the study and the eye tracker's functioning. We used the iViewX$_{TM}$ HED4 eye tracker (SensoMotoric Instruments, Berlin, Germany). This is a so-called head-mounted system: it is installed on the head so that participants can move and observe 'real' products. The output is a video from the respondent's viewpoint in which his/her visual gaze is depicted.

The participants read and signed the informed consent form, in which they agreed that their eye movements could be recorded; all data would be treated anonymously; and they could stop the experiment at any point. The experimenter then calibrated the eye tracker using a 9-point calibration panel.

The participants were asked to read one of two assignment texts. They had to imagine that they had to advise either a kindergarten (health motivation) or a student cafeteria (taste motivation) about which cereal out of five to buy. The kindergarten was looking for a product for preschool children. We expected that the association with children would motivate respondents to look for a healthy product. The other text stated that the student cafeteria was planning to offer breakfast from next semester on. Because our student sample would be the target group of this facility, we expected it to select the tastiest product. There was no time limit to make the food choice.

The experimenter then started the video recording of the eye tracker and presented the five cereals from which the respondents should choose one. The products were Kellogg's Original Cornflakes, Kellogg's Special K, Kellogg's Frosties, Coop Naturaplan Bioflakes and Prix Garantie Cornflakes (see Figure 3.2.1). These products are sold at the two largest food retailers in Switzerland. The products varied in their nutritional value, amount of presented information, target group, brand type, type of claims, design, presence of an FOP and price.[4] All products included a nutrition table, the product's name, brand name, ingredients and allergy information, price, expiry date, storage advice and information about product provenance.

As soon as respondents had selected a product, the experimenter stopped the video and asked them to complete a questionnaire with three items: familiarity with the chosen product (yes/no), the importance of offering tasty food and the importance of offering healthy food

[4]More information about the products and their characteristics, which had to be omitted due to limited space, can be acquired from the corresponding author.

for the kindergarten/student cafeteria (7-point Likert scales; higher scores indicated greater importance). These two items served as manipulation checks. Lastly, we asked for the demographics age and gender. At the end, the respondents were thanked, paid and debriefed about the experiment.

Figure 3.2.1. The five cereals presented in the study: Prix Garantie Cornflakes, Kellogg's Original Cornflakes, Naturaplan Bioflakes, Kellogg's Frosties and Kellogg's Special K

Data analysis

The data of the eye tracker were analysed as follows. First, the experimenter coded all forty-two videos in the analysis software Interact Version 8.50 (Mangold International GmbH, Arnstorf, Germany) by indicating which of the areas of interest (AOI) the participant's gaze was directed at and for how long. We defined nineteen AOI of which fourteen were package-related AOI (see Figure 3.2.2). All information on the packages was categorized into AOI, whereby the various nutrition and health information elements were labelled with separate AOI. We also assigned a separate AOI to each product (five product AOI).

An AOI was coded when the gaze of the respondent rested for 3 frames (i.e. 120 ms) or more on the predefined area. The observer coded a product AOI for the duration of the respondent's gaze on a product. At the same time, several package-related AOI could be assigned consecutively. If the gaze was missing for 8 frames or more (i.e. 320 ms), the code 'missing' was given. Videos in which more than 30% of the total duration was coded as missing were eliminated from the data set.

We used the SPSS statistical software package version 16 (SPSS Inc., Chicago, IL, USA) to calculate the descriptive statistics of the eye tracker videos and to analyse the questionnaire items. Unless stated otherwise, we analysed the relative durations and relative number of gazes per package-related AOI, and similarly per product AOI. The relative duration per package-related AOI was the absolute duration per package-related AOI divided by the total duration on all package AOI. The relative duration per product AOI was the absolute duration per product AOI divided by the complete video duration. We calculated two similar relative variables for the relative count using the number of gazes.

As we had a small sample and the eye tracker data were not normally distributed, we calculated the 95% confidence intervals around the medians using the bootstrapping method with replacement (1000 samples; Mooney & Duval, 1993). This was done with SYSTAT software version 12 (SYSTAT Software Inc., Chicago, IL, USA).

Every third video was also coded by a second observer to check the data quality. We calculated the reliability between the two observers using Cohen's kappa, which was substantial ($\kappa = 0.76$, $n = 1694$ for product AOI; $\kappa = 0.72$, $n = 626$ for package-related AOI; e.g., Landis & Koch, 1977).

Results

General description

The median net duration of the seventeen videos of the kindergarten condition and the fifteen videos of the student cafeteria was 109.70 s (interquartile range (IQR) = 76.08, 172.72). The net video duration did not include reading the assignment, unintentional gazes at the start and end of the video, and the product choice. The median number of items which the respondents looked at per video was 196.00 (IQR = 144.00, 243.25). After removal of the videos with more than 30% missing data, 13.5% (*Mdn*; IQR = 7.97, 22.24%) of the video durations were coded as missing. A majority of the respondents (nineteen of the thirty-two) reported not having been familiar with the cereals they chose.

Manipulation checks

We conducted Mann–Whitney tests to analyse whether the assignment affected respondents' importance rating of healthy food for the kindergarten/student cafeteria and, similarly, for the importance of tasty food. The effects of the assignment were in the expected direction and seemed to confirm our manipulation's success. Respondents in the student cafeteria condition considered tasty food to be marginally more important (*Mdn* = 7) than those in the kindergarten condition (*Mdn* = 6, *U* = 91.50, *p* = 0.07, one-tailed). Healthy food was significantly more important in the kindergarten condition (*Mdn* = 7) than in the student cafeteria condition (*Mdn* = 6, *U* = 83, *p*=0.03, one-tailed).

Respondents tended to need more absolute time to choose a product for the kindergarten (*Mdn* = 146.09 s, 95% CI 85.12, 205.64 s) than for the student cafeteria (*Mdn* = 102.45 s, 95% CI 79.44, 127.84 s), but this difference was not significant. The total absolute number of gazes did not differ between the kindergarten condition (*Mdn* = 19.39, 95% CI 130.00, 288.00) and the student cafeteria condition (*Mdn* = 199.34, 95% CI 169.00, 226.00). The mean duration per gaze also tended to be longer in the kindergarten condition (*Mdn* of mean gaze duration = 0.663 s, 95% CI 0.529, 0.864 s) than in the student cafeteria condition (*Mdn* of mean gaze duration = 0.539 s, 95% CI 0.412, 0.568 s). Longer mean gaze duration may indicate deeper information processing (Pieters & Warlop, 1999).

Effect of assignment over all products

We first examined which package-related AOI our respondents primarily perceived. The kindergarten group mainly looked at the nutrition table (Figure 3.2.2). It also paid a great deal of attention to the text, design, advertisements and ingredients/allergy information. Moreover, this group looked longer at the nutrition table (marginal effect for relative count) and more often at the ingredients/allergy information than the student cafeteria group. The latter group focused mainly on the design, and then on the advertisements, text and nutrition table. Additionally, these respondents looked longer at the logo/symbol and more often at the design of the product (marginal effect for duration) than the respondents of the kindergarten condition. In short, the assignment, and thus the type of motivation, seemed to affect what kind of package-related AOI participants perceived. The health motivation seemed to result in more interest in detailed nutrition information, whereas the taste motivation may have led to more attention to easy graphic information.

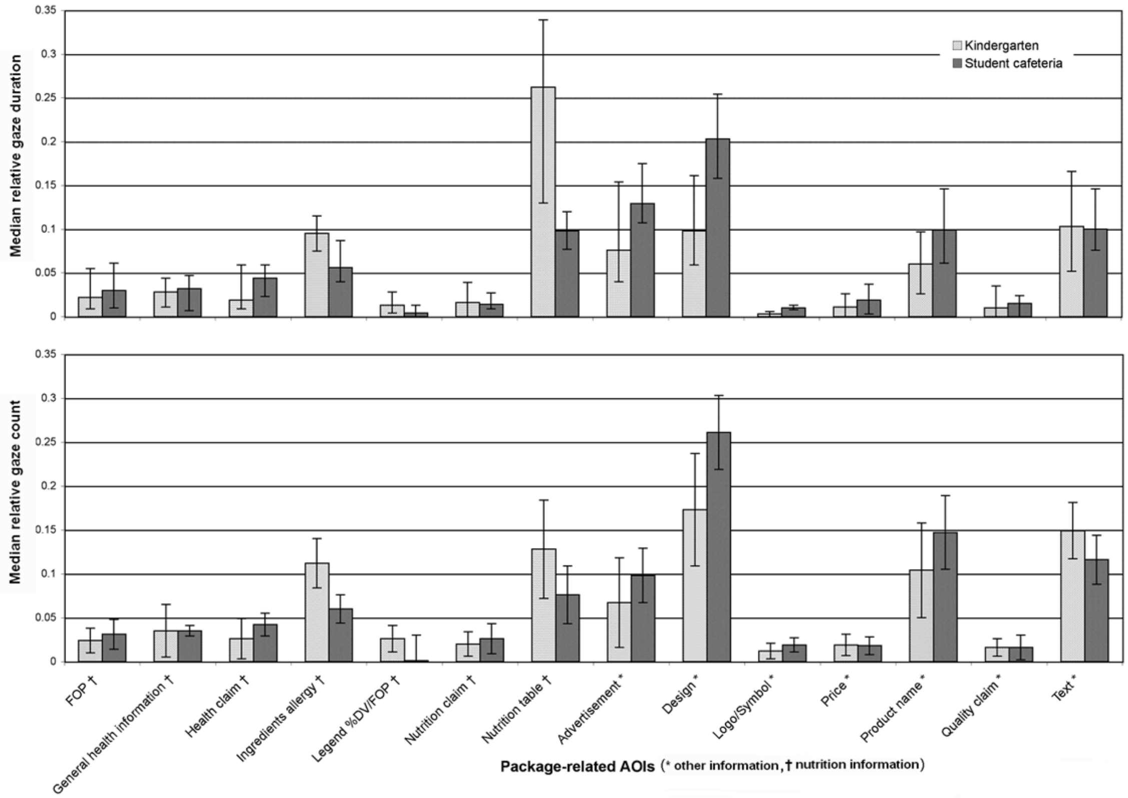

Figure 3.2.2. Median relative gaze durations and median relative gaze counts, with their 95% CI represented by vertical bars, for each package-related area of interest (AOI) for the kindergarten condition and the student cafeteria condition

The package-related AOI were then categorized into nutrition-related (‘nutrition’) information and nutrition-unrelated (‘other’) information, based on whether they provided information about health and the product’s nutritional value (Figure 3.2.2). These two groups of variables were first used to examine whether the assignment affected respondents’ visual attention to nutrition information compared with other information. The respondents in the student cafeteria condition looked significantly longer and more often at other items (44% for relative duration and 40% for relative count, respectively) than at nutrition information (20% and 16% respectively, Figures 3.2.3 and 3.2.4). Moreover, this group looked more often at other items than the respondents of the kindergarten condition (33%), but not longer. The latter group mainly regarded nutrition items and did this significantly longer (42%) and more often (25%) than the student cafeteria group.

The mean gaze durations showed a trend that the kindergarten respondents spent more time on nutrition information per gaze (*Mdn* of mean gaze duration = 1.144 s, 95% CI 0.725, 1.493 s) than the student cafeteria respondents (*Mdn* of mean gaze duration = 0.620s, 95% CI

0.489, 0.792 s). The mean gaze durations of the other information did not differ between the two conditions (*Mdn* of mean gaze duration = 0.561s, 95% CI 0.520, 0.643 s and *Mdn* of mean gaze duration = 0.533s, 95% CI 0.443, 0.606 s, respectively). This implies that the kindergarten condition did not balance respondents' attention for the two types of information; rather it seemed to increase respondents' attention to nutrition information compared with the other information and with the taste motivation.

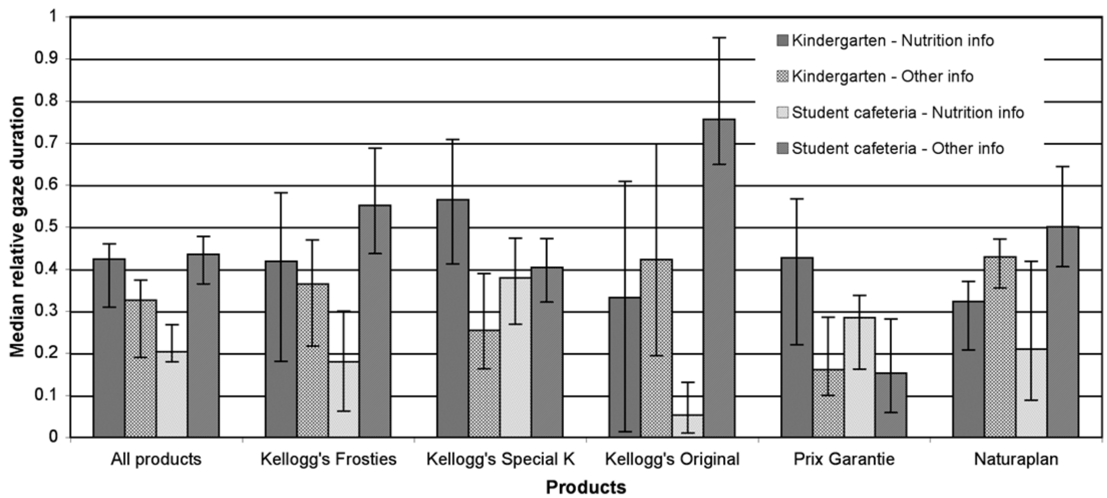

Figure 3.2.3. Median relative gaze durations, with their 95% CI represented by vertical bars, for the nutrition information and the other information over all products and per product, for the kindergarten condition and the student cafeteria condition

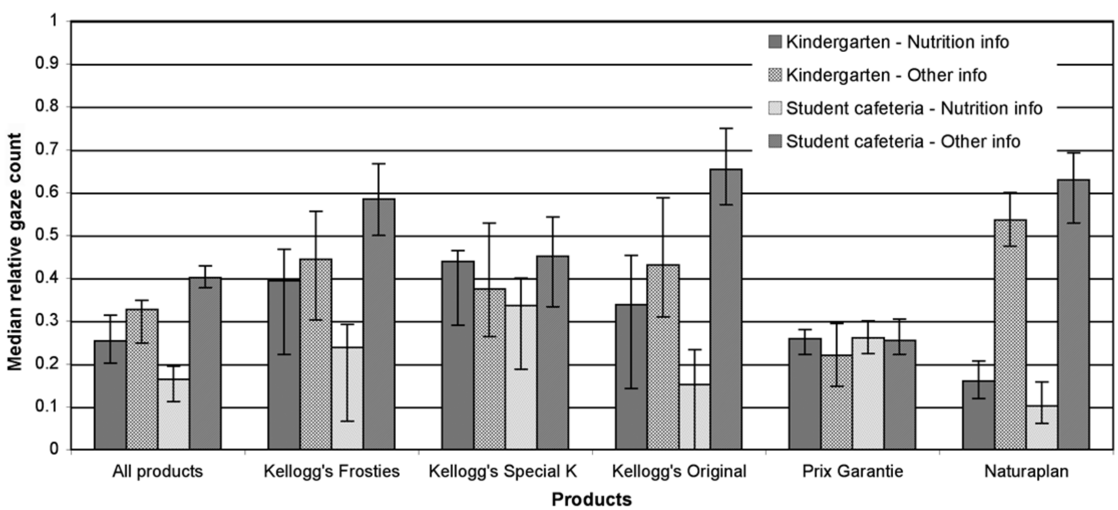

Figure 3.2.4. Median relative gaze counts, with their 95% CI represented by vertical bars, for the nutrition information and other information over all products and per product, for the kindergarten condition and the student cafeteria condition

Effect of assignment on each product

We then analysed whether the respondents of the two conditions perceived nutrition items and other items differently for each of the five products. The participants in the student cafeteria condition looked significantly longer and more often at other items than at nutrition items of Kellogg's Frosties, Kellogg's Original Cornflakes and Naturaplan Bioflakes (for relative duration only a marginal difference, Figures 3.2.3 and 3.2.4). They also showed equally long and just as frequent attention to nutrition items as to other items on Kellogg's Special K and Prix Garantie Cornflakes. The respondents in the kindergarten condition regarded the nutrition information of Kellogg's Special K significantly longer than the other information. Additionally, this group looked more often at other items on Naturaplan Bioflakes than at its nutrition items. Our results thus confirmed that not only the assignment but also the package type affected respondents' visual attention to nutrition items and other items.

Table 3.2.1. Number of respondents who never looked at and looked at least once at the nutrition table, front-of-package label (FOP) or either one of them, per product and condition

Product		Nutrition table			FOP			Nutrition table or FOP		
	Absolute gaze count	Student cafeteria	Kinder-garten	Overall	Student cafeteria	Kinder-garten	Overall	Student cafeteria	Kinder-garten	Overall
Kellogg's Frosties	0	7	6	13	11	12	23	6	5	11
	> 1	8	11	19	4	5	9	9	12	21
Kellogg's Special K	0	9	6	15	8	9	17	5	5	10
	> 1	6	11	17	7	8	15	10	12	22
Kellogg's Original Cornflakes	0	8	4	12	9	10	19	5	3	8
	> 1	7	13	20	6	7	13	10	14	24
Prix Garantie Cornflakes*	0	5	6	11	NA	NA	NA	5	6	11
	> 1	10	11	21	NA	NA	NA	10	11	21
Naturaplan Bioflakes	0	3	4	7	2	7	9	1	1	2
	> 1	12	13	25	13	10	23	14	16	30

NA, not applicable
* Prix Garantie Cornflakes do not include a FOP

Finally, we wanted to find out whether all respondents had perceived the information about the product's nutritional value on each of the five products. We therefore checked whether each participant had taken at least one look at either the nutrition table and/or the FOP of each product and we used the χ^2 test to analyse whether condition and product type affected respondents' notice of them or at least one of the two. Overall, more than twenty-one of the thirty-two respondents perceived at least one of the two information items on the five products (see Table 3.2.1, Nutrition table or FOP). It appeared that most respondents spotted the nutrition table or the FOP on Naturaplan Bioflakes and this was significantly more often than on the other products ($\chi^2(4) = 9.23$, $p = 0.06$). The majority of the respondents appeared to find the nutrition table in both assignments and this did not differ between the five products (all $\chi^2 < 6.23$, all $p > 0.18$, Table 3.2.1, Nutrition table). In the student cafeteria condition, more respondents missed the FOP on Kellogg's Frosties, Kellogg's Special K and Kellogg's Original Cornflakes, whereas most respondents noticed the FOP on Naturaplan Bioflakes (χ^2 (3) = 13.05, $p = 0.005$). This effect was mainly present in the student cafeteria condition (χ^2 (3) = 12.00, $p = 0.007$). Respondents may thus have found the nutrition table and the FOP more easily on Naturaplan Bioflakes than on the Kellogg's products.

Discussion

To the best of our knowledge, the present study is the first to examine consumers' visual attention to nutrition information on food products using an indirect measure. Our results indicate that at least 66% of the respondents perceived the nutrition label and/or FOP of each product (see Table 3.2.1, student cafeteria condition, for Kellogg's Frosties). This finding seems to agree with that of self-report studies, which revealed similar rates of nutrition label use (e.g., Guthrie et al., 1995; Nayga et al., 1998).

Noting the nutrition information does not imply that respondents also process and consider it in their food choice, especially if the product also includes other information that distracts people's attention. We therefore elaborate further on the implications of motivation and product design for nutrition information use in the following.

If consumers have a taste motivation, their visual attention to the other information on food products appears to overshadow their attention to the nutrition information. Our results also indicate that health motivation can stimulate people's attention for nutrition information and may lead to deeper information processing than taste motivation, especially of nutrition information. The health motivation namely resulted in longer mean gaze durations than the taste motivation, for the same amount of information.

The type of package appeared to affect people's notice of and attention to nutrition information. First, products with a simpler design, such as Naturaplan Bioflakes and Prix Garantie Cornflakes, attracted respondents' attention more easily to the nutrition information. More respondents noticed, for example, the FOP on Naturaplan Bioflakes. Second, the balance of nutrition and other information on the package seemed to play an important role. Products that mainly included nutrition information, such as Prix Garantie Cornflakes and Kellogg's Special K, seemed to attract relatively more of people's attention to the nutrition information than the other products. Thus, products with a simple design or with mainly nutrition information may help consumers to find the nutrition information. Products with a more crowded design or with mainly other information (i.e. Naturaplan Bioflakes) are not recommended to stimulate the use of nutrition information. A health motivation may then facilitate the detection of nutrition information.

To our knowledge, our study is the first to use an eye tracker to investigate consumers' visual attention to nutrition information while observing several food products. Our results of course do not indicate that consumers with a health motivation are also more likely to consider more nutrition information in their actual food choices. Further research is needed to investigate this interesting question.

The setup of our experiment was more realistic than the setup in previous studies (Goldberg et al., 1999; Higginson et al., 2002b; Jones & Richardson, 2007; Moorman, 1996; Rayner et al., 2001), but it also had a few drawbacks. We had to code the output of the mobile eye tracker subjectively, which may have affected our findings. However we had two observers code the videos using the same protocol; they showed reasonable agreement. Moreover, the mobile eye tracker is sensitive to head movements so that we had many missing fragments in the videos. Additionally, results from eye tracker studies do not indicate whether the respondents understood the information they perceived correctly.

To conclude, two factors appear to direct consumers' attention towards nutrition information on food products: health motivation and package design. An interesting implication of our results for, e.g., health educators and dietitians would be to prime people with a health goal before going shopping. Food producers may want to consider their products' design if they want to help consumers finding the nutrition information on their products.

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Chapter 3.3
Effectiveness and efficiency of different shapes of food guides

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Abstract

Objective: To compare the influence of a food guide's shape on its effectiveness and efficiency to convey nutritional information.

Methods: A between-subjects experiment was conducted by manipulating the graph's shape (circle, pyramid, or rainbow). Nutrition tasks were used to assess the effectiveness and eye-movement data (number/duration of fixations) to examine the efficiency of the formats. The data were quantitatively analysed (Chi square, ANOVA).

Results: There were no overall differences between the formats regarding effectiveness and efficiency. However, there were differences between the formats in effectiveness regarding 3 out of the 5 nutrition tasks. Furthermore, viewers' attention was drawn to different parts of the graph, depending on the format.

Conclusions and Implications: The results suggest that choosing different formats for practical nutrition communication does not play a major role in effectiveness or efficiency of this communication. However, different parts of the graph are more salient in various food guide formats.

Introduction

In many countries, there are food guides that are designed to educate people about healthy eating (Painter et al., 2002). Such graphs typically come in two types of shapes: hierarchical formats and circle formats (Painter et al., 2002). In both formats, the graph consists of several parts representing the different food groups (e.g., beverages, fruits and vegetables). The larger the area of these parts, the more of the corresponding food group should be eaten for healthy nutrition. In hierarchical formats, these parts are arranged from bottom to top, whereas in circle formats, these parts are arranged in a circle with different sized segments (e.g, the American MyPlate [US Department of Agriculture, n.d.] or the German circle of nutrition [Stehle, 2007]). There are essentially two possible hierarchical formats. Either the largest area is at the bottom and the smallest area is on the top of the graph (e.g., the pyramid of the Swiss society of nutrition [Walter et al., 2007]), or vice versa (e.g., the rainbow used in Canada's food guide [Health Canada, n.d.]). Furthermore, there are food guide shapes, such as the American MyPyramid (Britten, Haven & Davis, 2006; Haven, Burns, Britten & Davis, 2006), that do not fit in either of these groups.

An effective graph conveys the information in a way that viewers understand it and are able to use it. An efficient graph, on the other hand, enables viewers to quickly and easily process the graph and the information depicted in it. A nutrition graph's effectiveness can be assessed by qualitative methods, such as focus groups (Britten et al., 2006; Haven et al., 2006), and/or can be measured quantitatively by either asking nutritional knowledge questions or applying different tasks that require a solid understanding of the depicted nutritional information to be solved (e.g., rank different meals according to their healthiness; Britten et al., 2006; Eissing & Lach, 2003; Hunt et al., 1995; Ryan & Wilkins, 2001). A graph's efficiency, on the other hand, can be examined by analysing eye tracking data showing where, and for how long, people look when processing it.

To date, there have been some studies comparing the effectiveness of circle and pyramid formats. However, the results have been inconsistent. Hunt and colleagues (1995) compared different circle formats with different pyramid formats and found that individuals using one of the circle formats performed slightly better in nutrition tasks than participants using the pyramid formats. Eissing and Lach (2003), on the other hand, found a slight superiority of a three-dimensional pyramid in conveying nutritional knowledge to school children compared to different circle formats. Due to a lack of empirical data, therefore, it is not known which presentation format most effectively and most efficiently enhances individuals' understanding. The discussion about which of the format types should be chosen for effective and efficient nutrition education is thus mainly a theoretical one. The pyramid is criticized because it seems counter-intuitive to display the 'best thing' at the bottom and the 'worst thing' on top of the pyramid (Leitzmann, 2004). On the other hand, the circle is seen as advantageous because it resembles a plate and stresses the composition of a healthy diet rather than ranking the food groups into healthier and less healthy ones (Rodrigues et al., 2006).

The aim of this study was to examine the effectiveness and efficiency of three typical formats of graphical food guides (circle, pyramid, rainbow), which differ only in shape. The first research question was whether the three food guide formats differ in their effectiveness of conveying nutrition information required to judge different statements about healthful eating. The second research question concerned efficiency: it was explored whether differences exist between the three food guide formats regarding the number and duration of gazes required to process the graph.

Methods

Study Design

An experimental design was used to compare the graphs' effectiveness and efficiency. All participants were randomly assigned to viewing one of three shapes (circle, pyramid, rainbow) that included exactly the same information, depicted with the same pictures and colours. Thus, differences in the dependent measures could be attributed to the graph's shape. This design allows one shape's effectiveness and efficiency to be examined relative to the others.

Participants and Recruitment

The sample was recruited using a pretest in which 759 first-year students' familiarity with the food guide formats and their nutritional knowledge (measured with a short questionnaire consisting of 11 questions based on previous nutrition knowledge scales; Dickson-Spillmann & Siegrist, 2011; Dickson-Spillmann et al., 2011; Petrovici & Ritson, 2006) was assessed. The answers were ranked according to the number of correctly answered questions of the nutritional knowledge scale, and only the 206 individuals with the least correct answers were contacted by e-mail. Thus, it was ensured that all participants had to refer to the food guides during the experiment. Ninety-eight individuals (47.6%) participated in the experiment concerning the three food guide formats. Fifty-eight individuals (59%) were men, and the mean age of the participants was 20.5 years (*SD* = 2.0).

Data Collection

A remote contact free eye tracking system was used to measure participants' visual attention to the different formats as directly as possible (SMI RED). This system was located in a panel beneath a 19" computer screen on which the stimuli were shown with special software (Experiment Center version 2.2, SMI Germany).

The three graphical formats were based on three existing food guide formats: the pyramid of the Swiss association for nutrition (Walter et al., 2007), the circle of the German association for nutrition (Stehle, 2007), and the rainbow from Canada's official food guide (Health Canada, n.d.). However, these nutrition graphs use different colours, a variety of pictures of diverse sample food items, and do not display the same food groups. Therefore, three standardized food guides were used that were based on the three original graphs displaying the same colours, pictures, and segments to permit examination of potential differences caused by the format alone (see Figure 3.3.1). The colours were based on the Swiss pyramid, whereas the food groups and the depicted pictures were identical to those from the original Swiss pyramid (Walter et al., 2007).

The graph's effectiveness was measured with five statements, which participants had to judge as either correct or incorrect (see Table 3.3.1). A graph was considered more effective than the others, when it evoked more correct judgments. Two different types of statements reflecting two different types of information were used: information about the composition of a healthy diet (statements 1, 4, 5) and information regarding which food group a certain food product belongs to (statements 2, 3). The first group of statements was based on procedural nutritional knowledge questions by Dickson-Spillmann and Siegrist (2011), whereas the second group was derived from the food pyramid of the Swiss nutrition society (Walter et al., 2007). The number of statements was small to ensure optimal quality of eye movement data (i.e., no deterioration of calibration).

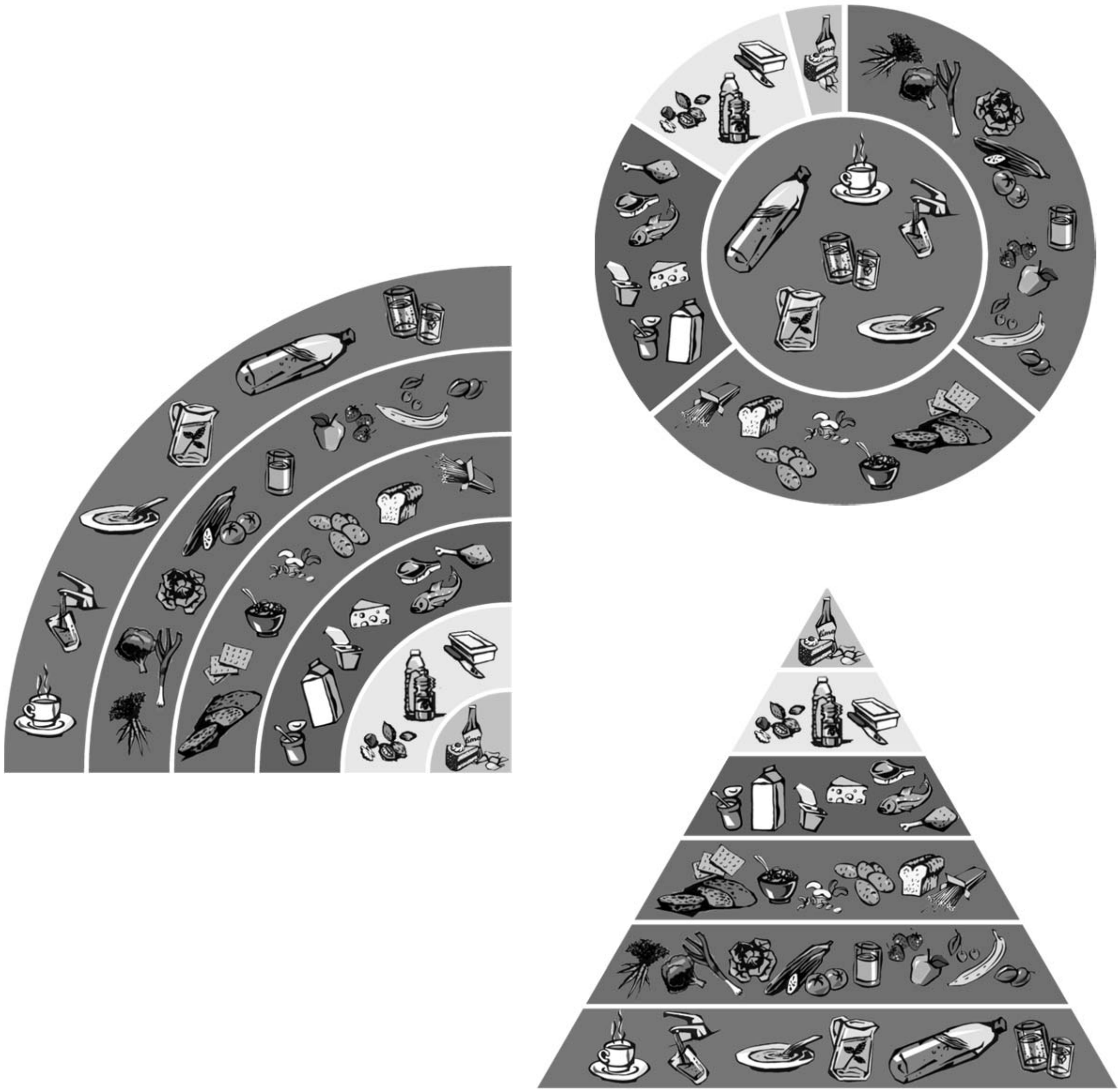

Figure 3.3.1. Formats of graphical food guides used for the study

Efficiency was measured by means of eye movement data. Studies examining eye movement data for different kinds of graphs have demonstrated that the processing of more complex and difficult graphs is associated with more and longer viewing of the graph (Ratwani et al., 2008; Renshaw et al., 2004). As all three graphs included identical information depicted in the same way, except for shape, it was expected that differences in the eye movement data would be due to the ease of interpretation of the shape. A shape was therefore considered more efficient than the others when the viewers needed less time and fewer gazes to process the graph.

Procedure

The eye tracking system was explained to participants in an eye tracking laboratory, and they provided written informed consent. Then, the system was calibrated. First, the participants saw their graph with the task of familiarizing themselves with it. Then, they proceeded to the statements with which the formats' effectiveness was measured. Each of the five statements was written on a single slide beneath the graph. The participants stated whether each statement was true or false. At the end of the study, the participants provided sociodemographic information and were financially compensated for their participation with 20 CHF (approx. 21 USD). The study was conducted according to the ethical principles for research and publication of the American Psychological Association (n.d.). Additional approval of the institutional review board was not needed for the present study (Ethikkommission ETH Zürich, n.d.).

Data Analysis

The eye tracking data were analysed with special software (BeGaze version 2.4, SMI Germany). First, seven areas of interest were designed for each graph (one for each segment, one for the entire graph). The software calculated the number of fixations and the total duration of fixations (cumulative) for each of these areas. A gaze was coded as fixation when it stayed within an area of ≤ 100 pixels for at least 80 ms. Two additional steps were performed to improve data quality. First, a missing data analysis was conducted, because eye tracking data often contain short sequences where no data are recorded (e.g., due to blinks). The percentage of such missing data sequences was calculated for each of the six single tasks (first impression, statements 1-5) separately, resulting in six datasets per participant. When one of these datasets contained more than 25% missing data, this dataset was excluded for the corresponding task, but this participant's other datasets were kept. Furthermore, datasets were excluded where the eye tracking system could not be successfully calibrated (e.g., due to light reflections on glasses). Overall, across all six tasks, 9% of the datasets were excluded.

The statistical tests were calculated using PASW version 18.0 (IBM SPSS, USA). Because the eye tracking data were not normally distributed (based on Kolmogorov-Smirnov test, ps < .05, confirmed by visual inspection), medians and corresponding 95% confidence intervals derived by bootstrapping (Efron & Tibshirani, 1993), and interquartile ranges are reported.

Results

When the answers of all five effectiveness tasks were summed up, participants who had seen the circle gave 3.24 (*SD* = 1.07) correct answers on average, participants who had seen the pyramid, 2.88 (*SD* = 0.75), and participants who had seen the rainbow, 2.74 (*SD* = 1.06). Results of a one-way ANOVA suggest that these mean values did not differ significantly, $F(2, 92) = 2.176$, $p = .119$. On the level of the single statements, however, there were some effects (see Table 3.3.1). However, no format was generally better or worse than the others. Furthermore, there was no type of statement (composition or belonging to a food group) that was solved better or worse by means of one of the three formats.

Table 3.3.1. Nutritional knowledge statements used to examine the effectiveness of the three formats with number of correct/incorrect answers for each graph format (effectiveness task)

			Frequencies (percentages)			
			Circle (n = 34)	Pyramid (n = 33-35)	Rainbow (n = 28-29)	χ^2
1	One should eat more dairy products than meat. (true)[a]	Correct answer	13 (38%)	4 (12%)	5 (18%)	7.044[b]
		Incorrect answer	21 (62%)	29 (88%)	23 (82%)	
2	Fruit juice belongs to the beverages, not to the fruit. (false)[a]	Correct answer	26 (76%)	29 (83%)	22 (76%)	0.597
		Incorrect answer	8 (24%)	6 (17%)	7 (24%)	
3	Lentils contain a large amount of protein and, therefore, belong to the same group as meat and fish. (false)[a]	Correct answer	24 (71%)	18 (51%)	24 (83%)	7.328[b]
		Incorrect answer	10 (29%)	17(49%)	5 (17%)	
4	It is not healthy if one eats almost exclusively fruit and vegetables. (true)[a]	Correct answer	27 (79%)	28 (80%)	15 (52%)	7.839[b]
		Incorrect answer	7 (21%)	7 (20%)	14 (48%)	
5	Oils and fats should be avoided whenever possible. (false)[a]	Correct answer	20 (59%)	20 (59%)	13 (46%)	1.232
		Incorrect answer	14 (41%)	14 (41%)	15 (54%)	

[a]Correct answers were derived from the Swiss food pyramid (Walter et al., 2007)
[b]$p < .05$

There were no differences between the three formats regarding total number of fixations and total fixation durations (see Tables 3.3.2 and 3.3.3). Thus, overall, all formats seemed to be equally efficient in conveying nutrition information. However, there were significant differences between the formats regarding the fixations' distribution on the segments of the graph (see Table 3.3.2): participants in the circle group paid more attention to the beverages and less to starchy foods than participants in the pyramid group. One explanation for this finding could be that participants paid relatively more attention to the food groups in the centre of the graphs (beverages in the circle, starchy food in the pyramid) than to those at the more peripheral areas.

Table 3.3.2. Descriptive eye tracking data for the general first impression task (medians [*Mdn*], 95% confidence intervals derived by bootstrapping [CI] and interquartile ranges [IQR])

			Circle (n = 33)	Pyramid (n = 33)	Rainbow (n = 26)
Fixation duration (sec)	Total	*Mdn*	19.25	17.92	19.14
		CI	15.89-23.85	13.97-24.64	14.74-23.00
		IQR	13.57-25.48	11.99-31.30	13.36-25.04
	Beverages[c]	*Mdn*	26.17[a]	15.21[b]	21.51[a,b]
		CI	23.49-32.60	12.34-18.80	18.38-25.40
		IQR	22.10-34.02	9.62-21.89	17.54-28.92
	Fruit and vegetables[c]	*Mdn*	18.34	16.84	19.86
		CI	14.60-22.67	14.06-21.09	17.10-23.56
		IQR	13.25-24.37	13.35-23.47	16.13-24.11
	Starchy foods[c]	*Mdn*	14.58[a]	19.61[b]	17.38[a,b]
		CI	12.33-17.25	17.83-22.81	15.32-20.18
		IQR	11.28-19.33	16.60-25.35	13.72-21.76
	Protein[c]	*Mdn*	14.94	18.04	15.68
		CI	13.48-18.51	14.27-19.22	12.92-18.26
		IQR	11.58-20.62	13.39-21.40	11.06-20.97
	Fats and oils[c]	*Mdn*	14.96	17.36	15.06
		CI	12.95-16.84	14.61-20.28	11.49-19.91
		IQR	11.49-19.23	12.49-21.14	8.89-22.75
	Snacks[c]	*Mdn*	7.24	7.56	5.93
		CI	5.06-8.22	6.46-9.26	4.43-8.77
		IQR	3.41-9.62	4.83-10.59	2.17-11.32
Number of fixations	Total	*Mdn*	54	55	58
		CI	45-66	36-64	44-66
		IQR	41-71	34-70	43-69
	Beverages[c]	*Mdn*	33.33[a]	17.39[b]	24.54[a,b]
		CI	29.44-38.67	15.34-23.21	20.86-28.00
		IQR	24.37-40.69	14.43-28.17	17.30-32.08
	Fruit and vegetables[c]	*Mdn*	18.75	20.00	22.94
		CI	17.19-23.38	16.95-22.48	20.83-25.00
		IQR	15.53-24.59	16.31-24.32	19.50-27.42
	Starchy foods[c]	*Mdn*	17.33	19.35	18.77
		CI	14.63-19.22	17.86-22.33	17.65-20.48
		IQR	13.14-21.13	17.58-24.17	15.07-21.21
	Protein[c]	*Mdn*	14.93	17.31	13.64
		CI	10.53-16.53	14.29-20.15	11.93-17.33
		IQR	9.18-17.16	13.11-21.00	10.83-19.11
	Fats and oils[c]	*Mdn*	13.33	13.91	11.71
		CI	10.96-14.71	11.76-15.55	9.45-15.86
		IQR	7.77-15.50	10.94-19.34	8.32-16.20
	Snacks[c]	*Mdn*	4.11	4.76	4.58
		CI	3.64-4.46	3.85-6.43	2.27-6.82
		IQR	3.29-5.23	3.49-8.13	2.11-7.64

[a, b]Values within the same row with different superscripts differ significantly from each other (non-overlapping 95%-CI).

[c]The values concerning the food groups are relative values (absolute value for each segment of the graph / total value for the entire graph).

Table 3.3.3. Descriptive eye tracking data for the knowledge statements (medians [*Mdn*], 95%-confidence intervals [CI] derived by bootstrapping and interquartile range [IQR])

			Circle (n= 30-33)[a]	Pyramid (*n* = 28-32)[a]	Rainbow (*n* = 24-26)[a]
Statement 1	Total fixation duration (sec)	*Mdn*	7.96	6.47	6.06
		CI	5.86-11.00	5.16-7.38	4.02-8.49
		IQR	4.65-14.29	4.82-8.77	3.67-9.34
	Total number of fixations	*Mdn*	27	22	21
		CI	19-35	18-24	15-29
		IQR	16-38	16-29	12-29
Statement 2	Total fixation duration (sec)	*Mdn*	3.66	4.02	3.73
		CI	2.73-4.62	3.22-5.01	1.73-5.02
		IQR	2.43-6.12	2.81-5.64	1.47-5.83
	Total number of fixations	*Mdn*	11	12	13
		CI	10-16	10-15	9-16
		IQR	8-18	9-18	6-18
Statement 3	Total fixation duration (sec)	*Mdn*	5.27	4.87	3.39
		CI	4.14-6.42	3.49-7.54	1.91-4.79
		IQR	2.87-7.48	3.00-8.69	1.87-5.36
	Total number of fixations	*Mdn*	16	15	11
		CI	14-21	12-21	7-16
		IQR	11-24	8-24	7-18
Statement 4	Total fixation duration (sec)	*Mdn*	1.38	1.77	1.51
		CI	0.83-2.07	0.93-2.67	0.79-2.54
		IQR	0.60-2.59	0.56-4.10	0.65-2.67
	Total number of fixations	*Mdn*	6	6	6
		CI	4-7	4-9	3-8
		IQR	3-9	2-10	3-10
Statement 5	Total fixation duration (sec)	*Mdn*	2.33	1.33	1.11
		CI	1.77-3.18	0.62-2.09	0.70-1.79
		IQR	1.67-3.42	0.41-2.69	0.34-2.18
	Total number of fixations	*Mdn*	8	5	4
		CI	6-10	3-6	2-6
		IQR	5-11	2-8	2-6

[a]Sample sizes vary within each condition due to the missing data analysis/calibration analysis, which was performed for each statement separately.

Discussion

The results of the present study showed that, despite the theoretical discussion about the different formats' advantages or disadvantages (Leitzmann, 2004; Rodrigues et al., 2006), overall, all formats appeared equally effective and efficient in practice. This equality of formats could also explain why previous studies comparing different formats found only small differences regarding the different food guide formats' effectiveness (Eissing & Lach, 2003; Hunt et al., 1995). However, there were some differences between the formats that should be considered. First, there were differences regarding the various formats' effectiveness in three of the five statements. The data thus suggest that all three formats have the potential to improve performance for some tasks, but less for others. The effectiveness of a certain format also seems to depend on the task at hand, which may also explain why previous studies using different tasks or knowledge questions to assess food guides' effectiveness showed inconsistent results regarding the superiority of one of the formats (Eissing & Lach, 2003; Hunt et al., 1995).

The present study has several limitations that should be considered. First, due to methodological restrictions, only a very small number of nutrition statements could be investigated. Furthermore, the first of these statements was rather difficult and only a minority of participants judged it correctly in every condition. It is, therefore, not clear whether this statement indeed had the potential to measure the food guide formats' effectiveness. Therefore, the results should be replicated with a more comprehensive set of nutrition statements. Second, a medium-sized sample was investigated. Therefore, it is possible that this study's design did not detect very small differences between the formats.

Implications for research and practice

The results of the present study show that, for practical nutrition communication (e.g., dietetic counselling), it does not matter whether a circle, a pyramid, or a rainbow is used. However, the eye movement data revealed that not all formats drew the viewers' attention to the same parts of the graph. Rather, the participants appeared to look more at the food groups that were displayed in the centre of the graph. Therefore, when using a graphical food guide for practical nutrition communication, one should keep in mind that the type of format used may influence which parts of the graph are salient. Further studies are needed to experimentally examine the influence of other graph characteristics in food guides, such as picture types, on the effectiveness and efficiency of nutrition communication.

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IV
General discussion

4.1 Overview

This dissertation formatively evaluates different visual health communication materials. It is based on the theoretical framework created by Grunert and Wills (2007) that describes the process of health communication. This model suggests that a health communication message must be looked at, perceived/processed, understood and used before it can have an impact on people's behaviour and that each step must be completed before proceeding to the next step. Furthermore, it assumes that this process is influenced by factors such as interest, knowledge and the format of the message (Grunert & Wills, 2007). Therefore, the studies presented in this thesis focus on attention processes from the search for information to the actual use of that information as well as on the role of factors that influence this process.

Graphs recommended for doctor-patient communication as well as nutrition labels and graphical food guides were examined as typical examples of two important dimensions of visual health communication - primary prevention and secondary prevention. As these two areas of health communication differ in many ways, different aspects of the above-mentioned framework are studied in each chapter of this dissertation. Part II focuses on the perception of the Paling perspective scale and on the processing and understanding of pictographs. Furthermore, numeracy was included in these studies as an important influencing factor. Part III contains studies regarding the search for and use of nutrition labels on food packages. Health motivation and potential barriers to label use were included as possible influencing factors in these studies to explore their role in these processes. Furthermore, the last study presented in Part III focuses on the evaluation and perception of different food guide graphs.

In this general discussion, the results of the studies presented in this dissertation are discussed. The structure of this chapter is as follows. First, the results of Parts II and III are discussed separately. For both parts, the key findings are first discussed in the context of the literature. Then, implications for health communication are derived from the results. Subsequently, the studies presented in this dissertation are evaluated and areas where further research is needed are described. Finally, a general conclusion is drawn regarding the entire dissertation.

4.2 Evaluation of graphs as a tool for doctor-patient communication

Graphs are recommended by several authors as a useful tool for risk communication (Lipkus, 2007; Paling, 2003; Visschers et al., 2009). The Paling perspective scale and pictographs are particularly recommended for communication between doctors and patients (Ancker et al., 2006; Apter et al., 2008; Lipkus, 2007; Nelson et al., 2008; Paling, 2003; Stallings & Paling, 2001). Furthermore, graphs are recommended explicitly for communication with patients with low numeracy (Apter et al., 2008; Nelson et al., 2008; Peters, 2008). The general aim of Part II, therefore, is to explore the association between numeracy and the processing and understanding of the Paling perspective scale and pictographs. In the next two sections, the results of these studies are discussed and implications for doctor-patient communication are given.

4.2.1 Usability of graphs for communication with patients with low and high numeracy

The results of the studies presented in Chapter 2.1 and 2.2 imply that there are important differences between persons with high and low numeracy in regard to the usability of graphs for doctor-patient communication. First, the eye movement data analysed in the study presented in Chapter 2.1 showed that the Paling perspective scale may be generally more difficult for persons with low numeracy to process than it is for persons with high numeracy, because they required more and longer gazes (for the association between longer and more frequent gazes and the processing of a graph; see Carpenter & Shah, 1998; Ratwani et al., 2008; Renshaw et al., 2004). These results are in line with a recent study that showed a clear correlation between numeracy and graphicacy, which means the ability to read and interpret graphs (Brown, Culver, Osann, MacDonald, Sand, Thornton, Grand, Bowen, Metcalfe, Burke, Robson, Friedman & Weitzel, 2011).

Second, the studies presented in Chapter 2.2 regarding the processing and understanding of pictographs suggest that this difference between persons with high and low numeracy could result from the type of information that people look for when they perceive a graph. Namely, the results imply that persons with high numeracy look for the numbers depicted in the graph and that these numbers then help them to understand the meaning of the depicted risk (see Studies 2 and 3, Chapter 2.2). For patients with low numeracy, on the other hand, graphs may only be useful when they can perceive and interpret the graph independent from the numbers that are depicted in it, because they can then extract a different, non-numerical dimension of information from the graph. However, if they are triggered in any way to focus on the depicted numerical information, the graph loses its ability to convey the meaning of the depicted risk information for them (see Studies 1 and 3, Chapter 2.2). These findings confirm the basic assumption of Peters' (2008) framework of numeracy, comprehension and use of numeric risk information, which is that persons with high numeracy pay more attention to numbers and extract more meaning from numerical information, whereas persons with low numeracy rely more on other information. Furthermore, the results described in Part II imply that this association may even be true when the numbers are depicted in a graphical format, which had been especially recommended for communication with patients with low numeracy (Apter et al., 2008; Nelson et al., 2008; Peters, 2008). However, the studies described in this dissertation did not reveal how this ‘other information’ can be defined, only that it does not consist of numbers and that it can be found in simple pictographs.

To conclude, this part of the dissertation shows that graphs are not necessarily an entirely different dimension of risk communication that differ from numbers in their very basic advantages and disadvantages. Not only numbers, but also graphs, seem to be more difficult for persons with low numeracy to interpret. One explanation for this may be that graphically depicted numbers seem to stay, in a way, numbers in disguise. Therefore, not every graph is able to overcome the disadvantages of numerical risk communication formats. However, Chapter 2.2 suggests that some graphs do have the potential to overcome these disadvantages. This conclusion is based on the results showing that some pictographs used in the studies in Chapter 2.2 did help persons with low numeracy to differentiate between high and low risks. The studies presented in Chapter 2.2 thus confirm the basic usefulness of pictographs for communication with persons with low numeracy, which was found in other studies showing that pictographs help to extract the numbers from the graph (Galesic et al., 2009; Garcia-Retamero & Galesic, 2009; Hawley et al., 2008). In addition, the studies imply that simple pictographs may be a type of graph that can be interpreted by persons with low numeracy, without their having to refer to the depicted numbers. This may facilitate the extraction of meaningful risk information for this group of people and may be a good way of communicating meaningful risk information to persons with low numeracy.

4.2.2 Implications for doctor-patient communication with graphs

From the results of the studies presented in Part II of this dissertation, two main implications for practical doctor-patient communication can be derived. First, some graphs, such as pictographs may indeed be a good way to support doctor-patient communication with regard to probabilistic information. However, they should be carefully designed and evaluated before they are used. For example, adding information that is actually believed to enhance the comprehensibility of a depicted risk, such as the risk comparison information in Study 1 presented in Chapter 2.2, may lead to the opposite effect and actually decrease understanding. Furthermore, in this dissertation, numeracy has been shown to play a role in the processing and understanding of graphs during doctor-patient communication. As it is probably not practical for doctors to test patients for their numeracy before giving them medical information, it may be more reasonable to design the graphs in such a way that they can be better understood by patients with low numeracy. The results of the present studies suggest that the graphs should not be too complex and should not include too much information so that they remain as easy to process as possible. Furthermore, it may be beneficial to choose graphs that do not display numbers very saliently in order to give persons with low numeracy the opportunity to process the graph without paying attention to the numerical information depicted in the graph.

Second, the results presented in Part II of this dissertation suggest that improving graphs alone may not be enough to reach the aim of patient-centred medical decision making for persons with low numeracy. The results imply that probabilistic medical information seems to remain difficult to process for this group of persons, even when it is depicted graphically. Therefore, persons with low numeracy should not be expected to make important medical decisions alone and based solely on this information. However, this is exactly what the informed decision making approach expects of patients. According to this approach, the only task of the doctor is to present the medical information in an understandable way, on which the patient can then base his/her decision (Charles et al., 1999). Therefore, it seems that for communication with patients with low numeracy, this type of medical decision making is not advisable. This is apparently also what persons with low numeracy feel themselves. A recent study by Galesic and Garcia-Retamero (2011) shows that over one third of their participants with low numeracy would prefer to have a more passive role in medical decision making than they currently have, whereas only slightly more than 10% of the participants with high numeracy expressed this wish.

In sum, this part of the dissertation suggests that the difficult task of explaining and discussing medical information, such as test results, with patients and guiding them on their way to a medical decision should remain a crucial part of a doctor’s job and cannot be transferred entirely to graphs. Furthermore, as it is not practical to measure a patient’s numeracy before treating him/her, doctors must sense which type of communication is appropriate for each patient. Thus, the role of the modern doctor regarding communication remains a challenging one. However, carefully designed graphs, such as pictographs, may be useful tools that can help doctors depict the meaning of medical information and face this challenge.

4.3 Evaluation of formats for nutrition communication

In Part III of this dissertation, two types of nutrition communication materials were examined: nutrition labels on food packages and graphical food guides. These materials are designed to promote healthy eating behaviour and enable people to eat healthfully by telling them what nutrients are in the food products they buy and how a healthy diet should be composed. Nutrition labels, on the one hand, are used directly by the consumer in the store and only he/she can know, whether he/she actually uses these labels for their purchasing decisions. However, if the labels are not used at all, they cannot have an impact on public health (see model by Grunert and Wills [2007]; Figure 1.1). Therefore, the aim of the studies presented in Part III that focused on nutrition labels (Chapters 3.1 and 3.2) was to comprehensively examine which factors play a role in the attention paid to and the use of nutrition labels. The focus of the study regarding different graphical food guides (Chapter 3.3), on the other hand, was different. As there is a theoretical discussion currently underway in the literature regarding which graphical format is best, the aim of this study was to compare the graphs with regard to their effectiveness and efficiency. In the next two sections, the results of these studies are discussed and implications for nutrition communication with labels and food guides are given.

4.3.1 Determinants of attention paid to and processing of nutrition communication formats

The results of the studies presented in Chapter 3.1 and 3.2 showed a medium use of nutrition labels. In the survey study presented in Chapter 3.1, 13% of the respondents reported that they never use labels, whereas 5% reported that they always use labels when buying food. The rest of the answers was distributed between these two extremes. In the eye tracking study presented in Chapter 3.2, about two thirds of all participants looked at the nutrition information on the package. These numbers lie between the frequency of label use reported by studies using self-report measures (ranging from 47% to 82%, Campos et al, 2011) and those reported by studies using direct measures, such as in-store observations and interviews (ranging from 17% to 27%; Grunert et al., 2010a; Grunert et al., 2010b). Thus, the results of the second part of this dissertation suggest that nutrition labels may indeed be used in Switzerland by a considerable number of persons and that they may indeed have an impact on public health.

The studies in Chapters 3.1 and 3.2 further examined factors influencing the use and processing of nutrition labels. The results of these two studies consistently suggest that two factors are of major importance in the use of nutrition labels: the subjective importance of healthy nutrition and factors inhibiting label use. First, the results suggest that persons for whom it is very important to eat healthfully and who know much about health and nutrition use labels more often. This is in line with other studies that have found such health-related factors of importance for label use (Grunert et al., 2010a; Grunert et al., 2010b; Nayga, 2000; Nayga et al., 1998; Neuhouser et al., 1999; Petrovici & Ritson, 2006; Satia et al., 2005) and is, therefore, not very surprising. However, the study presented in Chapter 3.1 suggests that this dimension of health-related factors may be broader than expected. Namely, the results of this study showed that viewing eating as something positive and focusing on the enjoyment of eating seems to be associated with less-frequent label use. Therefore, this may imply that, at the other end of the spectrum from placing importance on healthy eating, people equate healthy eating with something tasteless and un-hedonic and, therefore, avoid nutrition communication materials.

With regard to the non-health-related inhibiting factors concerning label use, the results of the studies presented in Chapter 3.1 and 3.2 suggest that they are many. Chapter 3.1 implies that some of the inhibiting factors reside within the customer him-/herself. For example, having stronger shopping habits and low numeracy was associated with less frequent label use. Strong shopping habits may make label use seem unnecessary to consumers because they always buy the same products and know them very well. Furthermore, lower numeracy has been shown to be associated with a decreased understanding of nutrition labels (Rothman et al., 2006), which can, according to the framework of Grunert and Wills (2007), also lead to less label use. So far, these results confirm the reasons given by participants to Gorton and colleagues (2009) for not using labels, namely that they are not interested in healthy eating, that they do not need more information about food, that they do not understand labels and that they have priorities other than healthy eating. The eye tracking study presented in Chapter 3.2 showed that factors outside of the consumer, such as package design, can also be important for label use. Namely, the results of this study suggest that cereal packages displaying a large amount of information can distract a viewer’s attention from nutrition information. This finding is in line with the results of another eye tracking study that showed that size and location influence a viewer’s visual attention paid to the labels (Bialkova & Van Trijp, 2010).

Similarly, the study presented in Chapter 3.3 also implies that the design of health communication materials can influence to which part of the visual stimulus a viewer's attention is drawn. This eye tracking study compared three food guide formats (a circle, a pyramid and a rainbow) and found that the parts in the centre of the graphs were looked at more and longer. However, this guidance of visual attention did not influence how well the information depicted in the graph was understood. All three formats were equally effective and efficient in depicting information about healthful eating. This suggests that the discussion of which format is best for nutrition communication (Leitzmann, 2004; Nestle, 1998; Rodrigues et al., 2006) is indeed a theoretical one that should not have too large an effect on the practice of dietetic counselling.

4.3.2 Implications for nutrition communication with nutrition labels and food guides

Overall, nutrition labels seem to be used primarily by the persons that are interested in health and nutrition. If public health communicators also want to reach other audiences, the following two implications can be derived from the results presented in Chapters 3.1 and 3.2. First, they can try to raise the level of health consciousness within the entire population. Chapter 3.1 suggests that it may be beneficial to focus on the more positive aspects of health and nutrition, as the general motivation to live healthily was a stronger predictor of label use than the more disease-related factors, such as believing that there is an association between diet and disease. Therefore, it may be reasonable to stress that a balanced diet will keep one healthy and to focus less on the fact that eating an unhealthy diet can lead to diseases. Furthermore, it may be useful to emphasize that eating healthy food does not necessarily mean restraining oneself from eating anything enjoyable and that a healthy diet can also include snacks or fatty foods, if they are eaten in moderation. Indeed, this seems to be an important topic for health communication in general as Jeanne Goldberg concluded more than ten years ago, 'that 'good for you' and 'tastes good' are not mutually exclusive' (Goldberg, 2000, p. 646). Chapter 3.1 suggests that this factor still merits health communicators' attention.

Second, label use may be supported when the barriers that keep customers from using them are lowered. Chapter 3.1 suggests that back-of-package nutrition information in the form of text or a table that is broadly used in Switzerland may be too difficult to process for persons with low numeracy. Perhaps, more modern approaches to front-of-package labelling that provide consumers with additional information, such as the food's relation to one's daily nutrient needs or traffic light symbols may help to reach this aim (Campos et al., 2011; European Heart Network, 2003). Furthermore, Chapter 3.2 implies that the package design offers an opportunity to enhance consumers' label use. If nutrition label use is to be increased, it may be reasonable to avoid 'crowded' package designs that display a large amount of visual stimuli other than nutrition information.

Concerning the food guide formats, Chapter 3.3 suggests that it is not important whether a circle, a pyramid or a rainbow is used for nutrition communication. As the viewers' attention may be drawn to certain salient parts of the graph, however, it may be advantageous for dietetic counsellors to explain the graphs to their clients in order to make sure that every part of the graph is perceived and paid attention to.

4.4 Evaluation of the studies presented in this dissertation and implications for future research

In this dissertation, a multi-method approach is applied to formatively evaluate the processing of different health communication materials as well as the influence of several external factors on these processes. The multi-method approach, composed of a combination of self-report surveys and interviews, experiments and eye tracking, has proven to be an appropriate approach to this research field. The eye tracker was an especially useful tool in order to broaden the set of results gained for this dissertation. The eye tracker studies were used as explorative instruments in order to deliver ideas that could be studied in more detail with other methods (Part II). Furthermore, assumptions about the relationships between certain influencing factors and the attention paid to or the processing of health communication materials that stem from studies using self-report measures or theoretical discussions were examined by eye tracking experiments (Part III). This procedure resulted in broad and comprehensive results that evaluated the process of health communication from many different angles.

It became very clear during this research that eye tracking studies should always be combined with other methods, such as experimental approaches, or only be applied in areas with a profound theoretical basis. The reason for this lies in the fact that eye tracking data offer only information about gaze directions, fixations durations and fixation counts, which require a considerable amount of interpretation before they can help answer research questions. For example, if someone looks for a very long time at a certain area on a visual stimulus, it may mean that he/she is processing this area very deeply because he/she is interested in this area. However, it could also be the case that the person does not understand the depicted information and is attempting to process it more deeply in order to understand it. Which of these explanations is more adequate cannot be judged by considering the eye movement data alone. Therefore, it is very important to have an interpretational aid to help the researcher integrate these results into a larger picture with other results or theoretical frameworks. Furthermore, eye tracking studies are rather time-consuming and labour-intensive. Therefore, it is often only possible to examine a small sample of persons (approximately 15-20 persons per condition). Thus, it can also be reasonable, from a methodological perspective, to apply other instruments, such as self-report surveys, to the same or similar research questions in order to examine the questions using larger samples.

The theoretical framework created by Grunert and Wills (2007) that was used for this dissertation has proven to be an appropriate theoretical basis as it offered many different points of view on the formative evaluation of health communication materials. In this way, it was possible to conduct different studies focusing on several aspects of the entire process of health communication, ranging from information search to the actual use of materials. It should be mentioned that, although this dissertation is restricted to formative evaluation and, because of this, to the examination of procedural aspects of health communication, the author considers it very important for health communicators to discover whether a health communication message indeed translates into the intended health behaviour. However, this rather belongs to the field of summative evaluations (Thomas, 2006), which was beyond the scope of this dissertation. Nevertheless, formative evaluation also contributes largely to effective and efficient disease prevention and health promotion because it can give indications of why and based on which processes certain health communication efforts do not result in healthier behaviour and others do. Furthermore, when interpreting the results gathered in this dissertation, it should be kept in mind that only a small sample of health communication materials and research questions could be evaluated. Therefore, the general implications given in this chapter should be used with care and the results presented in Chapters 2.1 to 3.3 should be replicated in and completed with further studies to confirm these implications.

In the context of doctor-patient communication using graphs, the results of this dissertation suggest that two areas of research should be further examined. First, the association between graph processing/understanding and numeracy should be explored in more depth. In addition to pictographs and the Paling perspective scale, more types of graphs should be examined in order to determine which exact characteristics of graphs, rather than specific graphs, help persons with low numeracy to process the graphs and understand the meaning of medical risk information. In this way, clear evidence-based recommendations could be given for the use of visual aids in the context of doctor-patient communication. Chapter 2.2 implies that pictographs can be useful for this purpose. Therefore, comparing graphs with pictographs may be a good starting point for such studies. Furthermore, Part II has shown that not only numbers, but also graphs, are probably more difficult to process for persons with low numeracy and that this group of persons may extract a different type of information from graphs than persons with high numeracy do. Chapter 2.2 gives an early indication that persons with low numeracy do not focus on numbers. However, the results do not reveal what type of information this group is paying attention to instead. Therefore, further studies should investigate whether this lack of focus on numbers is indeed an important aspect of graph processing for persons with low numeracy. If so, the types of information that are helpful for persons with low numeracy should be explored.

Second, on a more methodological level, it may be interesting to further explore the difference between self-reported numeracy (subjective numeracy) and numeracy measured with mathematical problems (objective numeracy) in the context of studies regarding graphical doctor-patient communication. In most of the studies presented in this dissertation, only subjective numeracy was used in order to prevent high non-response rates and to include the self-efficacy aspect of numeracy. In Study 2 presented in Chapter 2.2, however, objective numeracy was also included. The results of this study suggest that these two measures are positively correlated, but not very highly (.44). Furthermore, the two measures were associated with slightly different aspects of having a numerical focus: counting the icons of a pictograph and mentioning numbers in the interview. Therefore, it should be further examined whether the results found in Part II of this dissertation would be different if a more objective numeracy measure was used.

In the context of nutrition communication, this dissertation shows three areas in which future research may give interesting new insights. First, the role of factors that inhibit or promote nutrition label use should be further explored. Chapters 3.1 and 3.2 suggest that health motivation and inhibiting factors are the most important determinants of nutrition label use. However, Chapter 3.1 also shows that, together with sociodemographic factors, these factors explain only about one third of the variance of frequency of label use. Therefore, it should be further examined which other variables explain the rest of this variance. As there already exists a large body of research examining the role of health motivation variables in this context, it may be reasonable for future studies to focus on inhibiting factors and their impact as compared to health motivation. Chapters 3.1 and 3.2 found only a few examples of inhibiting factors. Therefore, it may be interesting for future studies to find a more comprehensive model of factors that inhibit nutrition label use. According to the results found in Part III of this dissertation, these studies should include factors that reside within the individual, such as behaviours and skills, as well as factors that reside outside the individual, such as the design of a package.

Second, the studies presented in Part III of this dissertation focused mostly on back-of-package labels as this type of label has been used in Switzerland for quite some time and is therefore known by most persons. However, more and more front-of-package labels are also appearing on products in Switzerland. Therefore, further studies are needed that explore the use and understanding of both types of labels. First, it would be interesting to understand whether the role of the influencing factors found in Chapter 3.1 are the same in the context of front-of-package labels or whether the use of this type of label is predicted by other factors. Second, Chapter 3.2 showed that back-of-package labels seem to be used more often when persons with health motivation choose a cereal than when persons with taste motivation choose a cereal. Front-of-package labels, on the other hand, were used about equally often by both of these groups. Therefore, it is not clear whether front-of-package information is considered for the same purpose as back-of-package information. Furthermore, it does not become clear in Chapter 3.2 which nutrients the participants actually look at on the different labels in order to make their decision. Future studies should address why and how front-of-package labels are used.

Finally, Chapter 3.3 showed no large differences between the three different formats of graphical food guides (circle, pyramid, rainbow). This implies that which of the graphs is used does not play a major role in the practice of dietetic counselling. However, food guides can also differ with regard to other characteristics, such as the depicted food groups, the type of pictures used and recommendations given (Hunt et al., 1995; Painter et al., 2002). Whether these differences have a major impact on the understanding of the food guides should be systematically examined before it can be generally concluded that all of the food guide formats are equally well suited for nutrition communication.

4.5 Conclusion

Based on the framework created by Grunert and Wills (2007), this dissertation formatively evaluated several visual health communication formats. Overall, the results suggest that health communication materials are often sought, perceived and understood by those who are interested in a certain topic, know much about this topic and/or do not have problems understanding the given information. Other factors influence this process and define these groups of persons. This dissertation has shown that health motivation and numeracy may be factors that health communicators should keep in mind when designing new materials for health communication. Furthermore, the results suggest that theoretical expectations regarding the usefulness of certain characteristics of graphs are not necessarily beneficial or relevant in practice. Things that are thought to be helpful, such as risk comparison information, may not be perceived at all or may make the graph more difficult to process or understand, whereas things that are believed to impede the comprehensibility, such as a pyramidal graph depicting the ‘worst’ thing on top, may not hinder the graph’s effectiveness and efficiency in practice. Pretesting health communication materials based on procedural frameworks, such as the one proposed by Grunert and Wills (2007), is thus worthwhile.

To conclude, visual communication materials can be useful tools for health communication when they are carefully designed and evaluated. However, health communicators should be aware that they must not expect these tools to automatically reach persons with low numeracy or low health motivation. If these groups are to be reached, health communicators must engage in further efforts and carefully examine whether their message is actually received and processed.

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Summary

Health communication materials can only have an impact on people's health if they are actually used and understood by the targeted audience. Therefore, this dissertation aims to evaluate health communication materials in the fields of doctor-patient communication and nutrition communication to investigate whether and how these materials are used and understood. The studies presented in this thesis focus on attention processes that range from the search for information to the actual use of that information as well as on the role of factors that influence this process. Part I gives an overview of the field of health communication and explains why the dissertation focuses on doctor-patient communication and nutrition communication. Furthermore, Part I describes the relevant literature and the methods used in this dissertation.

Part II describes several studies that examine the association between numeracy and medical risk communication between doctor and patient with the Paling perspective scale (Chapter 2.1) and pictographs (Chapter 2.2). Chapter 2.1 presents an eye tracking study which aims to generate ideas about why this graph might or might not be helpful for persons with low numeracy. The results suggest that the Paling perspective scale is difficult to process for persons with lower numeracy and that this group processes the graph less efficiently. Chapter 2.2 describes three studies that explore whether pictographs are helpful in conveying the meaning of numerical risk information to persons with high or low numeracy and how these two groups of persons process the graph. The results of these studies suggest that simple pictographs may be understandable for persons with high and low numeracy. Furthermore, the results imply that persons with high numeracy rely more on the numbers depicted in this type of graph than persons with low numeracy.

Part III presents several studies regarding the search for and use of nutrition labels on food packages (Chapters 3.1 and 3.2) as well as one study regarding the perception and understanding of food guide graphs (Chapter 3.3). Chapter 3.1 describes a survey study conducted to test a comprehensive model of the frequency of nutrition label use consisting of three predictor groups: sociodemographic variables, health-related aspects and inhibiting/ motivational factors. The results suggest that health-related variables are the most important predictor group for the prediction of frequency of nutrition label use, followed by motivating factors, such as shopping habits and viewing eating as something positive. The subsequent chapter (Chapter 3.2) presents an eye tracking study that aimed to examine in more detail

how much attention consumers pay to nutrition information when they are looking at real food packages and whether being motivated to choose healthy food products leads to increased attention being paid to nutrition information. The results suggest that health motivation leads to more attention being paid to nutritional information on the package and that crowded package designs may distract the viewers' attention from nutrition information. The last study presented in Part III (Chapter 3.3) focuses on the evaluation and perception of different food guide graphs. First, to measure the graphs' effectiveness, an experiment was conducted to examine whether seeing a pyramid, a circle or a rainbow resulted in more correctly solved nutrition tasks. Second, to measure the three shapes' efficiency, an eye tracker was used to examine whether one of the graphs was easier to process. The results suggest that the three graph formats do not differ with regard to effectiveness and efficiency overall.

Finally, the key findings of these studies are then discussed comprehensively in Part IV. Furthermore, the implications for health communication as well as for further research are given based on the results of Parts II and III. In short, the results of this dissertation suggest that health communication materials are often sought, perceived and understood by those who are interested in a certain topic, know much about this topic and/or do not have problems understanding the given information. Furthermore, this dissertation has shown that health motivation and numeracy may be factors that health communicators should keep in mind when designing new materials for health communication.

Zusammenfassung

Materialien zur Gesundheitskommunikation können nur dann einen Einfluss auf die Gesundheit haben, wenn sie vom Zielpublikum auch wirklich benützt und verstanden werden. Deshalb ist das Ziel dieser Dissertation, Materialien zur Gesundheitskommunikation in den Bereichen Arzt-Patienten-Kommunikation und Ernährungskommunikation zu evaluieren und zu untersuchen, ob und wie diese Materialien benützt und verstanden werden. Die Studien die in dieser Dissertation vorgestellt werden, konzentrieren sich auf Aufmerksamkeitsprozesse, die von der Suche nach Information bis zum eigentlichen Gebrauch der Information reichen sowie auf die Rolle von Faktoren, die diesen Prozess beeinflussen. Teil I gibt einen Überblick über das Gebiet der Gesundheitskommunikation und erklärt, wieso in dieser Dissertation Arzt-Patienten-Kommunikation und Ernährungskommunikation untersucht wurden. Zudem werden in Teil I die relevante Literatur und die Methoden, die in dieser Dissertation verwendet wurden, vorgestellt.

Teil II beschreibt mehrere Studien, die den Zusammenhang zwischen Numeracy und medizinischer Risikokommunikation zwischen Arzt und Patient anhand der Paling perspective scale (Kapitel 2.1) und Piktogrammen (Kapitel 2.2) untersuchen. Kapitel 2.1 stellt eine Eye Tracker Studie vor, die Ideen generieren soll, weshalb diese Grafik für Pesonen mit tiefer Numeracy gut funktioniert - oder eben nicht. Die Resultate lassen vermuten, dass die Paling perspective scale für Personen mit tiefer Numeracy schwierig zu verarbeiten ist und dass diese Gruppe die Grafik weniger effizient verarbeitet. Kapitel 2.2 beschreibt drei Studien, die herausfinden sollen, ob Piktogramme hilfreich sind, um Personen mit tiefer Numeracy numerische Risikoinformationen zu kommunizieren. Die Ergebnisse lassen annehmen, dass einfache Piktogramme sowohl für Personen mit hoher als auch für Personen mit tiefer Numeracy verständlich sein können. Zudem deuten die Resultate dieser Studien darauf hin, dass sich Personen mit hoher Numeracy mehr als Personen mit tiefer Numeracy auf die Zahlen konzentrieren, die in dieser Grafik dargestellt werden.

Teil III stellt mehrere Studien vor, die die Suche nach Nährwertinformation und den Gebrauch von Nährwertkennzeichnungen auf Lebensmittelverpackungen untersuchen (Kapitel 3.1 und 3.2), sowie eine Studie, in der es um die Wahrnehmung und das Verständnis von Grafiken für Lebensmittelempfehlungen geht. Kapitel 3.1 beschreibt eine Umfragestudie, die durchgeführt wurde, um ein umfassendes Modell zu testen, das die Häufigkeit voraussagen soll, mit der die Nährwertkennzeichnungen auf Lebensmittelverpackungen

benutzt werden. Es werden dabei drei Gruppen von Prädiktoren beachtet: Soziodemographische Variablen, gesundheitsbezogene Faktoren sowie hemmende/ motivierende Faktoren. Die Resultate zeigen, dass gesundheitsbezogene Variablen die wichtigste Prädiktorgruppe für die Voraussage des Gebrauchs von Nährwertinformationen auf der Verpackung von Lebensmitteln darstellen, gefolgt von motivationalen Faktoren wie Einkaufsgewohnheiten und der Empfindung, dass Essen etwas Positives darstellt. Das nachfolgende Kapitel (Kapitel 3.2) stellt wiederum eine Eye Tracker-Studie vor, die zum Ziel hatte, genauer zu untersuchen, wie viel Aufmerksamkeit Konsumenten den Nährwert-kennzeichnungen widmen, wenn sie echte Lebensmittelverpackungen anschauen und ob es die Aufmerksamkeit auf die Nährwertinformationen erhöht, wenn die Konsumenten das Ziel haben, gesunde Lebensmittel auszuwählen. Die Ergebnisse lassen annehmen, dass die Motivation, gesunde Lebensmittel auszuwählen, dazu führt, dass den Nährwertinformationen auf der Verpackung mehr Aufmerksamkeit geschenkt wird. Verpackungen, die sehr viel zusätzliche Information enthalten, scheinen zudem die Aufmerksamkeit von den Nährwertangaben abzulenken. Die letzte Studie, die in Teil III vorgestellt wird (Kapitel 3.3), bezieht sich auf die Evaluation und die Wahrnehmung von verschiedenen Grafiken zur Darstellung Lebensmittelempfehlungen. Auf der einen Seite wurde die Effektivität der Grafiken gemessen, indem ein Experiment durchgeführt wurde, um festzustellen, ob mit einer Lebensmittelpyramide, einem Lebensmittelkreis oder einem Lebensmittelregenbogen mehr Aufgaben zu verschiedenen Nährwertgruppen richtig gelöst werden konnten. Andererseits wurde zudem die Effizienz der drei Formate gemessen, indem mittels eines Eye Trackers untersucht wurde, ob eine der Grafiken einfacher zu verarbeiten war. Die Ergebnisse lassen vermuten, dass sich die drei Grafikformate hinsichtlich Effektivität und Effizienz nicht unterscheiden.

Abschliessend werden in Teil IV die wichtigsten Ergebnisse dieser Studien umfassend diskutiert. Zudem werden Implikationen für die Gesundheitskommunikation sowie für weitere Forschungsfragen aus den Ergebnissen der Teile II und III herausgearbeitet. Über alle Studien hinweg lassen die Ergebnisse dieser Dissertation vermuten, dass Materialien zur Gesundheitskommunikation häufig von denjenigen Personen gesucht, wahrgenommen und verstanden werden, die an diesem Thema sehr interessiert sind, über das Thema viel wissen und/oder keine Probleme haben, die kommunizierten Informationen zu verstehen. Diese Dissertation gibt zudem Hinweise darauf, dass Gesundheitsmotivation und Numeracy Faktoren sind, die bei der Herstellung von neuen Materialien zur Gesundheitskommunikation beachtet werden sollten.

Acknowledgements

I started this dissertation with a quote and I would like to end it with one. John Donne once said: ‘No man is an island, entire of itself […]’ (and certainly no woman is, either). Therefore, there are many persons who greatly contributed to this thesis and I would like to thank them for their support during the last three and a half years.

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